GAO

Report to the Chairman, Committee on Armed Services, House of Representatives

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SIMULATION TRAINING

Management Framework Improved, but Challenges Remain

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The Honorable Ronald V. Dellums
Chairman, Committee on Armed Services
House of Representatives

Dear Mr. Chairman:

In response to your request, this report describes the evolving coordination of simulation activities under the auspices of the Defense Modeling and Simulation Office within the Office of the Secretary of Defense. It also addresses the Army's efforts to strengthen the management of its simulation programs, with a particular focus on the acquisition of the Close Combat Tactical Trainer. This report contains recommendations to the Secretaries of Defense and the Army.

We are sending copies of this report to the House and Senate Committees on Appropriations; the Chairman of the Senate Committee on Armed Services; the Director, Office of Management and Budget; and the Secretaries of the Army, Navy, and Air Force. Copies will also be made available to other interested parties upon request.

This report was prepared under the direction of Paul L. Jones, who can be reached on (202) 512-3990. Other major contributors are listed in appendix III.

Sincerely yours,

Frank C Conahan

Frank C. Conahan
Assistant Comptroller General

Executive Summary

Purpose

Congress has supported increased use of simulation technology but has had some concerns about the Department of Defense's (DOD) management of this area. Accordingly, the Chairman of the House Armed Services Committee asked GAO to study DOD's efforts to coordinate simulation technology's use agencywide. The Chairman also asked GAO to review the Army's Close Combat Tactical Trainer (CCTT) acquisition plan to ensure that it provided for (1) high-level management oversight, (2) system interoperability, and (3) adequate integration of the system with more traditional forms of training for greater cost-effectiveness.

Background

Although DOD uses simulations for a variety of purposes, this report focuses on simulations in military training. Advances in simulation technology are bringing about what many consider to be a revolution in military training. In recent years, however, Congress and various study groups have expressed concern about the lack of Defense-wide guidance, coordination, and management of simulation technology.

On November 30, 1992, the Army awarded a contract to initiate the engineering design of the CCTT—a simulation system to train armor and mechanized infantry forces. CCTT is the first of a planned series of simulators to train armor, aviation, air defense, artillery, and engineer forces. The series is called the Combined Arms Tactical Training system. CCTT is expected to have an acquisition cost of over $400 million and a 15-year life-cycle cost of nearly $1.3 billion. Current milestone dates call for decisions on full production to be made in 1997.

Results in Brief

DOD's coordination of the development and use of simulation technology is still evolving. The Defense Modeling and Simulation Office (DMSO) and the Joint Staff are key players. DMSO is working to foster increased use of simulation technology across a broad spectrum of functions affecting the military services; it is focusing particularly on the linking of diverse simulations. Two Joint Staff directorates support the simulation requirements of regional commanders in chief (CINCs) who report to the Secretary of Defense through the Chairman of the Joint Chiefs of Staff. DMSO has made progress in working to enhance DOD simulation capabilities, but its future is clouded by a lack of permanent staff. The two Joint Staff directorates have overlapping responsibilities in the simulation area and interpret them differently. This has resulted in some duplication of effort. The Joint Staff has begun a reassessment of its organization, which provides an opportunity to eliminate unnecessary overlap.

The Army recently reorganized its command structure to ensure high-level management oversight over the acquisition of CCTT and other simulation programs. It also mandated that CCTT be interoperable with other simulation systems.

The Army expects CCTT to complement and in some instances enhance training traditionally done in the field. It expects that the CCTT's cost will be offset by reductions in traditional training funds. However, life-cycle cost data on the system are tentative for now, and the most appropriate mix of CCTT and traditional field training has yet to be determined. The Army plans a more definitive assessment of these issues before CCTT's 1997 full-production decision. Even then, future system upgrades are planned that could affect cost and training effectiveness.

Principal Findings

DOD-Wide Coordination Is Still Evolving

In June 1991, the Deputy Secretary of Defense authorized the creation of DMSO to coordinate and provide guidance for simulation issues DOD-wide. DMSO has made progress responding to its mandate. It has formulated a management plan and helped organize Defense-wide working groups to facilitate coordination between the services and DOD organizations. The management plan outlines two important areas that require attention: (1) a master plan to guide simulation development and use across DOD and (2) measures to ensure that the services implement adequate controls over the development and modifications of simulations. In fiscal year 1993, DMSO expects to issue a DOD directive outlining requirements for a coordinated approach for developing and using simulations. A draft of the directive encourages information sharing, investments in common technologies, and the formulation of common standards for simulation development.

DMSO faces challenges, however. To date, the office has been unsuccessful in obtaining permanent staffing authority and hiring a civilian director. Staff temporarily on loan from the services are starting to be recalled for other assignments, which could create gaps in institutional knowledge and hamper mission continuity.

Representatives from two Joint Staff directorates have worked with DMSO in various working groups. However, within the Joint Staff, the roles and

responsibilities concerning simulation support for CINCs are not clearly delineated. For example, both directorates claim some responsibility for assessing CINC simulation requirements, and officials in each have voiced different perspectives on how it should be done. Further, each directorate has been surveying the CINCs to determine their simulation needs. This results in duplication and inefficient use of resources. However, the Joint Staff has begun to reassess various aspects of its organizational staffing and structure. These reassessments, expected to be completed in fiscal year 1993, provide opportunities to consolidate functions and eliminate duplication.

Army Acts to Ensure High-Level Management Oversight and System Interoperability

Army plans call for CCTT and subsequent simulations in the Combined Arms Tactical Training system to each be acquired as a major program and subjected to specific milestone reviews by Army executives. To implement this plan, the Army recently reorganized its command structure for acquiring simulations. It created the Simulation, Training, and Instrumentation Command and designated a project manager to oversee development, testing, and fielding of CCTT and other related systems.

To ensure interoperability among simulation systems, the Army required that CCTT have an "open systems design." In such a design, neither interfaces between pieces of hardware nor interfaces between sections of software depend on vendor-specific or proprietary equipment. Also, the Army is developing operational standards for CCTT that could be useful for other simulation systems, including those of other military services.

The Army Is Uncertain About the Most Cost-Effective Mix of Simulation and Traditional Field Training

In October 1991, an executive review council approved the engineering design of CCTT. The council based its approval on preliminary, yet-to-be-validated data on likely system costs and training effectiveness. Cost and training effectiveness are scheduled to be reassessed before the Army decides whether to proceed with the full-rate production of CCTT in 1997. Even then, however, some uncertainties could remain because a number of upgrades are planned for the system.

Army commanders are trying to accelerate the CCTT acquisition. Under a "Quick Start" program, the Army decided to field 68 limited-capability CCTT units before it tested system operations or validated cost and training effectiveness. Continued pressures to expedite fielding are likely and could cause the Army to limit planned testing and related assessments. However, shortcutting these critical reviews could limit (1) the Army's

ability to more definitively assess the effectiveness of CCTT, (2) full disclosure of future program costs for CCTT, and (3) insight into potential funding trade-offs between simulations and field training.

The Army does not definitively know the combination and quantity of Combined Arms Tactical Training systems it will need or the extent to which they will be linked together to train higher echelons. Plans for CCTT and other Combined Arms Tactical Training systems initially focused on integrating simulations and field training at the battalion level. However, Army officials now plan to use CCTT at the platoon and company level.

Recommendations

GAO recommends that the Secretary of Defense

- ensure that DMSO is properly staffed to carry out its assigned responsibilities and
- eliminate the overlap between the two Joint Staff directorates by clearly delineating each directorate's roles and responsibilities in the simulation area.

GAO also recommends that the Secretary of the Army ensure that all testing, cost analyses, and training effectiveness assessments are completed and fully considered before decisions are made about full-rate production of CCTT.

Agency Comments and GAO's Evaluation

DOD concurred with the majority of GAO's findings and recommendations on DMSO and the Army's management of the CCTT program (see app. II for complete DOD comments). However, concerning the recommendation to eliminate duplicative responsibilities within two directorates of the Joint Staff, DOD stated that modeling and simulation responsibilities are shared by several joint staff directorates, not just those cited in this report. DOD expressed the view that this does not constitute unneeded duplication of effort.

Since GAO found unnecessary overlapping functions between two Joint Staff directorates, that resulted in inefficient use of resources, DOD's acknowledgement that even more joint staff directorates have modeling and simulation responsibilities does not dispel GAO's concern, but reinforces it. Moreover, for DOD to express the opinion that there is no unnecessary duplication before its own studies of the issue are completed seems to undermine the purpose of the studies.

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Abbreviations

CATT	Combined Arms Tactical Training system
CCTT	Close Combat Tactical Trainer
CINC	Commander in Chief
DIS	Distributed Interactive Simulation
DMSO	Defense Modeling and Simulation Office
DOD	Department of Defense
GAO	General Accounting Office
JSID	Joint Simulation and Interoperability Division
J-7	Joint Staff Plans and Interoperability Directorate
J-8	Joint Staff Force Structure, Resources, and Assessment Directorate
REFORGER	REturn of FORces to GERmany
SIMNET	SIMulation NETworking

Introduction

The nature of modern warfare demands that air, land, and sea forces complement each other as a team. U.S. forces are no longer preoccupied primarily with training for a well-defined threat in Europe. Instead, they must be prepared to respond to multifaceted crises that could develop quickly in any part of the world. This requires repetitive, realistic, and stressful training in as close to combat conditions as is permissible in a peacetime environment.

Increasingly, advances in computer technology are facilitating the ability of simulations to complement and in some cases offer significant advantages over traditional forms of training.

Training Simulations

The services traditionally have used hundreds of training devices to model or simulate various aspects of combat, weapon systems, and terrain in support of training activities. Training devices range from the simple—such as simulated explosives and plywood terrain boards that replicate the terrain of a given battle area—to the highly technical—such as sophisticated laser gunnery systems that simulate the effects of direct-fire weapons and computer-supported multimillion dollar aircraft simulators.

Computer simulations are growing in importance as training devices because they add realism to training and potentially reduce training-related costs. During the 1970s, computer technology facilitated the development of multimillion dollar weapon system trainers that generally focused on developing individual skills. For example, flight simulators were used to train pilots. As microprocessors became widely available, Department of Defense (DOD) components sought more comprehensive ways to use this technology to train their forces. Technology achievements in the 1980s permitted the networking of multiple, homogeneous weapon system simulators into an interactive, electronic battlefield where military crews could obtain realistic training on selected tasks.

DOD categorizes simulations into the following three classes on the basis of their technical and physical structure:

- Computer simulation models: Armed forces, weapon systems, and the interaction between them are primarily represented by computer code and run from a computer keyboard. Such simulations are not designed to replicate specific weapon systems. Rather, they provide a view of the

battle on a map, which is displayed on a video monitor with units on the map shown as icons (unit symbols). Computer models can differ greatly in the detail they contain and may involve some human interaction while the model is running. War games fall into this category.

- Weapon system simulators: Individual weapon systems are modeled and typically controlled by a human operator. Simulators replicate the performance characteristics and appearance of a weapon system to help teach individual skills. Aircraft simulators are typical examples. Principal emphasis is now on networking multiple weapon system simulators together in an interactive format to create a large scale simulated training environment extending beyond the training of individuals and crews to include multiple crews and units. One example is the networking of tank simulators on an electronic battlefield.
- Instrumented exercises: Actual troops, weapon systems, and support systems interact in as real an environment as possible, short of combat. Electronic instrumentation is used to collect, analyze, and distribute data on force elements. Examples include the Army's National Training Center in California, the Air Force's Red Flag in Nevada, and the Navy's Top Gun Facility in California.

Technology developments in the 1990s are beginning to provide opportunities to connect war games with simulators and connect both of these with instrumented training ranges.[1] Opportunities will exist to connect multiple simulations from different services to provide joint training. Training experts consider these developments a revolution in military training.

Benefits of Simulation Training

Some military officials perceive simulations to be a poor alternative to traditional field training exercises. However, there is increasing recognition that while traditional field training exercises are important, they can have significant limitations—limitations that can be overcome to a certain extent through the use of simulations. For example, traditional field training (such as Army tank maneuver or gunnery training) can be limited by the high cost of fuel, training ammunition, and repair parts; lack of space; safety and environmental concerns; and lack of time required to prepare for and undertake such exercises. A prior GAO report addressed the transition of REFORGER (REturn of FORces to GERmany) exercises in

[1]Unless otherwise stated, the use of the term simulation in this report refers collectively to the broad range of simulations and simulator systems used for training purposes.

Germany from the use of large-scale field exercises to the increased use of simulation.[2]

Computer simulations also have limitations, but they provide important training opportunities and capabilities not always feasible in traditional field exercises. Large-scale field exercises that emphasize battle planning and command and control of forces are time-consuming and often produce significant downtime for lower echelon personnel. Computer simulated exercises permit more concentrated and repetitive training for tactical operations—such as tank maneuvers for ground forces—as well as command and control operations for leaders and their staffs. Moreover, computer simulated training provides opportunities for individuals and units to enhance their skill levels before and after participating in traditional field exercises. Finally, simulations permit training that is not otherwise practical in peacetime, such as the use of electronic warfare that might be restricted due to safety and environmental factors.

Simulations played a key role in preparing U.S. forces for ground operations in Operation Desert Storm.[3] As a result, there is growing recognition that the military needs to use this technology along with traditional field training. However, as noted in several of our recent reports, the most appropriate mix between traditional field and simulation training has not been established.[4]

Simulation Networking—a Breakthrough Technology

Beginning in 1983, the Defense Advanced Research Projects Agency and the Army jointly pursued a project to develop technology for constructing large-scale computer networks to create a battlefield environment where combat teams and their related support elements could operate together on a regular basis. This over $200-million effort led to the creation of a training system that came to be called SIMNET (SIMulation NETworking). The technology associated with SIMNET has provided the foundation for the Army's current efforts to acquire an advanced network simulation system as well as DOD-wide efforts to foster use of this technology.

[2]Army Training: Computer Simulations Can Improve Command Training in Large-Scale Exercises (GAO/NSIAD-91-87, Jan. 30, 1991).

[3]Operation Desert Storm: War Offers Important Insights Into Army and Marine Corps Training Needs (GAO/NSIAD-92-240, Aug. 25, 1992).

[4]In addition to reports already cited, also see Army Training: Various Factors Create Uncertainty About Need for More Land (GAO/NSIAD-91-103, Apr. 22, 1991).

The SIMNET Battlefield

In SIMNET, numerous computer-driven simulators (configured around a mock-up of the interior of an armored vehicle) are electronically linked to form a common combat arena or battlefield. Each simulator contains high-technology electronics, microcomputer processing, and visual displays with three-dimensional graphics to help operators believe they are in actual combat. Through the simulator's viewports, which are actually small video monitors, a SIMNET participant sees a simplistic three-dimensional landscape and other simulated vehicles participating in the interactive exercise. From the driver's position, an operator can maneuver the simulated tank across the terrain; and from the gunner's station, an operator can locate an enemy target and engage the main gun to hit it. The commander can simulate the rotation of the tank's turret to help locate targets and survey the battlefield. A sense of realism is enhanced through auditory cues that replicate activities expected during a battle. They include replications of the whine of the 1,500 horsepower turbine engine and realistic sounds normally associated with the loading and firing of the main gun.

SIMNET also incorporates some battlefield participants that are generated by the computer. These participants are called semi-automated forces because a trainer initiates a combat task from a computer work station, but the task is performed automatically according to specified war-fighting doctrine and tactics that are programmed into the system. Semi-automated forces may be both friendly and opposing forces. Other functions are initiated from computer work stations to depict air and artillery strikes and provide combat service support by dispatching fuel, maintenance, and ammunition trucks when needed.

SIMNET also has a built-in data collection and analysis system that records a complete history of a simulated battle, including orders to take actions, the resulting actions, and the impact of the actions. The data are stored so that battle participants can analyze the results later in after action reviews.

Evolution of SIMNET

SIMNET was first demonstrated in May 1986, at the Army's Armor Center in Fort Knox, Kentucky, using local area communications networks. A second SIMNET site was activated in March 1987 at Grafenwohr training center in Germany. Long-haul networks to link SIMNET units operationally at distant sites were tested in 1988 to connect Fort Benning, Georgia; Fort Rucker, Alabama; Cambridge, Massachusetts; and Washington, D.C., with Fort Knox, Kentucky. Ultimately, 236 simulators were acquired and placed in 11 sites in the United States and Germany; they have remained in

continual use as training devices. Army forces used SIMNET to prepare for Operation Desert Storm.

While the Defense Advanced Research Projects Agency transitioned control of the completed SIMNET training system to the Army, it expanded the SIMNET concept to other cutting edge technologies in the networking area. In one area, the Defense Advanced Research Projects Agency is pursuing technology to connect the three different classes of simulations, including those from different services, for simultaneous operations. Portions of this technology were demonstrated in recent exercises in Korea and Germany.

Success of the SIMNET program has led to the formalization of the networking protocols as an industry standard known as Distributive Interactive Simulation (DIS) standards. Formalization of DIS standards is ongoing through government-, industry-, and academia-sponsored workshops and should support the networking of multiple simulations, including those from various services. The Army, with support from the other services and DOD organizations, is providing much of the leadership for this initiative. The DIS concept has been expanded into several other service-specific initiatives. For example, the Air Force's Armstrong Laboratory has developed a network to test DIS applicability to fighter aircraft. The Navy is developing a Tactical Combat Training System to provide real-time interactive simulated training for ships, aircraft, and submarines while they are at sea.

SIMNET Limitations

SIMNET was viewed as a revolution in training. It enhanced the capability for combat crews and units to train repetitively in a fully interactive combined arms environment with elements of the military forces represented either by operator-controlled simulators or computer-generated, semi-automated forces.[5] However, SIMNET had limitations. Several studies were undertaken by the Army to assess SIMNET's training benefit. These studies, most of which produced nonquantitative results, showed positive training benefits but noted that some tasks were being trained incorrectly and some essential tasks were not trained at all. These studies identified some key limitations in SIMNET, including the following:

[5]Combined arms training refers to collective training that includes combat, combat support, and combat-service support units. Combat units comprise infantry and armor forces. Combat support refers to fire support and assistance such as artillery and combat engineering. Combat-service support refers principally to logistics and administrative support such as supply and transportation.

- Only two major ground combat vehicles were represented.
- Few restrictions were imposed on vehicle movements. Terrain irregularities such as ditches, gullies, or stream beds were not adequately portrayed. Trees and forests did not present obstacles since vehicles could run through trees without losing speed.
- Fields of view from the video monitors were smaller than in actual vehicles, and the gunnery systems were unable to identify targets at realistic distances.
- Commanders' view of the battlefield was constrained. In the case of a real tank, commanders could peer outside through a popped hatch and have a 360-degree view.

Additionally, an independent assessment of the SIMNET software by a systems engineering company found many technical errors in computer code written to depict system performance.

Replacing SIMNET With CCTT

Before assuming full responsibility for SIMNET in 1990, the Army was already addressing SIMNET's deficiencies. According to Army officials, simply improving SIMNET was not considered a viable option for the following reasons: (1) improvements in technology were making the system obsolete; (2) the Army did not have adequate documentation of the SIMNET programming code, which could have limited competition for the successor project; and (3) the Army wanted to develop a family of advanced simulators to train all of its forces under an umbrella concept known as the Combined Arms Tactical Training (CATT) system.

The Army envisions the CATT system as a combination of training devices that can each train a unique segment of the Army's forces but can also operate in a combined arms exercise. Five training devices are currently included in the CATT concept. The first device is the Close Combat Tactical Trainer (CCTT) for armor and mechanized infantry forces. Other CATT systems that may be developed include an Aviation Combined Arms Tactical Trainer, an Air Defense Combined Arms Tactical Trainer, an Engineering Combined Arms Tactical Trainer, and the Closed Loop Artillery Simulation. The Army is also considering other potential systems for intelligence and electronic warfare.

The baseline CCTT will have numerous advanced capabilities over SIMNET and will be further upgraded after it is fielded through a process of preplanned product improvements. These improvements are the desired features that program managers perceived as too expensive to include in

the basic system or those that they believed could not be technologically produced at the time.

The Army released a Request for Proposal for the CCTT acquisition on November 5, 1991, and on November 30, 1992, it awarded a cost reimbursable contract in excess of $409 million for the engineering and manufacturing development phase of the acquisition cycle. Current milestone dates call for decisions on full-rate production to be made in 1997.

Concerns Regarding Simulation Management

Since 1976, reports by various DOD and service study panels have reflected concerns about the management of modeling and simulation activities. A 1988 report to the Secretary of Defense from a Task Force of the Defense Science Board indicated that computer-based, simulated scenarios offer the only practical and affordable means by which joint commanders and their staffs can exercise decision-making skills, test war plans, and train as closely coordinated forces. However, the Board study identified problems with the management of modeling and simulation activities. The study revealed, for example, that service and individual joint commanders did not coordinate with each other when building or modifying automated training simulations, and therefore built duplicate models. A 1989 DOD Inspector General report on DOD war-gaming activities stated that because the Office of the Secretary of Defense and the Joint Chiefs of Staff lacked policies and guidance on war-gaming activities, DOD components were purchasing new equipment, developing models and data base software, and renovating facilities to expand joint war-gaming capabilities without coordinating these efforts. The report recommended that DOD designate an office of primary responsibility within the Joint Chiefs of Staff to establish policies and procedures for war games and exercises.

In its August 1990 Authorization Report for Fiscal Year 1991 Defense Authorizations, the House Armed Services Committee expressed concerns about the adequacy of DOD-wide coordination involving computer simulation technology. The Committee recommended the establishment of a central office to coordinate the technology throughout DOD and raised questions about the adequacy of CCTT program management. The Committee was especially concerned that the acquisition strategy be structured to ensure that normal milestone reviews be conducted and that operational testing receive the required emphasis. The Committee was also concerned about system interoperability; the integration of CATT component systems with other training activities, from a

cost-effectiveness standpoint; and the mix of CATT systems needed. Related concerns had also been expressed in an Army Audit Agency report.[6]

Objectives, Scope, and Methodology

The Chairman of the House Armed Services Committee, requested that we review DOD's efforts to coordinate simulation technology's development and use agencywide. The Chairman also specifically asked us to review the Army's plan for acquiring CATT systems to ensure that it provided for (1) high-level management oversight, (2) interoperability with other systems, and (3) integration of the system with more traditional forms of training for greater cost-effectiveness.

To assess DOD's role in providing coordination and guidance involving simulations, we interviewed knowledgeable officials at the Defense Modeling and Simulation Office (DMSO); the Operational Plans Directorate (J-7) and the Force Structure, Resources, and Assessment Directorate (J-8) of the Joint Staff; the Commander of the Joint Warfare Center, Hurlburt Field, Florida; the Commanding General of the Marine Corps Combat Development Center in Quantico, Virginia, and other knowledgeable Marine Corps training officials; and modeling and simulation officers from the Navy and the Air Force. We also interviewed the Executive Director of the National Training Systems Association in Arlington, Virginia, an organization representing the manufacturers of training simulations and other training systems. We reviewed prior evaluations by Defense Science Boards and the DOD Inspector General, documentation on DMSO's objectives and investment initiatives, and congressional reports on the subject. DMSO's mission encompasses the use of modeling and simulation in the areas of education, training, and military operations; research and development; test and evaluation; analysis; and production and logistics; however, our review focused on training.

To determine the status of the CCTT acquisition and plans for other CATT components, we interviewed officials from the Army's Deputy Chief of Staff for Operations, Arlington, Virginia; the CCTT development team members at the Simulation, Training, and Instrumentation Command, Orlando, Florida; the Training and Doctrine Command's System Manager for CATT, Fort Knox, Kentucky; the Chief of the Army Model and Simulation Management Office, Crystal City, Virginia; officials at the Combined Arms Command, Fort Leavenworth, Kansas; Training and Doctrine Command's Analysis Center, White Sands Missile Range, New Mexico; and Defense Advanced Research Projects Agency, Arlington,

[6]Networking Training Devices, U.S. Army Audit Agency (SO 90-10, Apr. 16, 1990).

Virginia. We reviewed numerous reports on SIMNET, the CATT Master Plan, the statement of work and the contract for CCTT, the CCTT Test and Evaluation Master Plan, preliminary CCTT cost information, and independent evaluations by the Army Audit Agency and Army Science Boards. We participated in a demonstration employing an existing SIMNET training simulator, a tank driver simulator, and an Abrams M1A1 tank in Fort Knox, Kentucky. We conducted our review in accordance with generally accepted government auditing standards between November 1991 and December 1992.

DOD-Wide Coordination of Simulation Activities Is Still Evolving

DOD-wide guidance and coordination of simulation technology is evolving under DMSO, which was created in 1991 within the Office of the Secretary of Defense. DMSO is responsible for providing guidance and coordination and fostering simulation networking across DOD and the military services. DMSO is making progress in responding to its mandate, but it has not fully developed (1) a master plan to guide simulation development and use across DOD or (2) measures to ensure that the services implement adequate controls over the development and modifications of models and simulations. The Office of the Secretary of Defense has not yet approved permanent staff for DMSO.

The Joint Staff, under the Chairman of the Joint Chiefs of Staff, also have roles in the simulation area, with a particular focus on supporting regional commanders in chief (CINCs) who report to the Secretary of Defense through the Chairman.[1] While the missions of DMSO and the Joint Staff are complementary, two Joint Staff directorates appear to have overlapping responsibilities and interpret them differently. As a result, some duplication of effort and inefficiencies exist. However, the Joint Staff has begun to reassess its organizational structure and staffing and may clarify the roles and responsibilities of these two directorates in the simulation area.

Efforts to Strengthen Coordination and Management of Simulation Activities

In June 1991, in response to the growing concerns about the inadequacy of DOD coordination and the lack of guidance dealing with simulation activities, the Deputy Secretary of Defense established DMSO under the Director of Defense Research and Engineering. DMSO has a key role in strengthening the use of models and simulations across a wide range of activities, including education, training and military operations; test and evaluation; research and development; analysis; and production and logistics.

[1]Reporting to the Secretary of Defense are assorted defense agencies, three military departments (the Army, the Air Force, and the Navy), and the CINCs of the unified and specified commands, who also operate under the strategic direction of the Chairman, Joint Chiefs of Staff. Unified commands are composed of forces from two or more services and may be organized on a geographical or regional basis, such as Atlantic Command, European Command, Pacific Command, and Central Command. Specified commands are organized on a functional basis and are normally made up of forces from a single service.

Defense-Wide Structure

DMSO operates under the guidance of a high-level executive council, chaired by the Director of Defense Research and Engineering.[2] DMSO has operated with a core staff of between six to eight persons assigned on a temporary basis and augmented it with contractor support. Much of DMSO's work is accomplished through the use of working groups comprised of representatives drawn from Defense agencies and the military services.

In fiscal year 1993, DMSO expects to issue a DOD directive outlining requirements for a DOD-wide approach for developing and using models and simulations. A draft of the directive encourages information sharing, investments in common technologies, and the formulation of common standards for simulation development. The draft also requires the services and DOD organizations to implement management systems to oversee their modeling and simulation activities and to facilitate interservice coordination. Modeling and simulation offices have been or are being established by the services.[3]

Defense-Wide Standards and Interoperability

DMSO is seeking to foster the development of Defense-wide standards, data bases, and communications capabilities in the simulation area. In this way, the office intends to promote simulation system interoperability and stimulate the development and use of joint models and simulations. DMSO pursues these goals through functional and technical working groups and by funding various simulation projects submitted by the services, Joint Staff, and Defense agencies. Illustrative of the types of projects funded are the following:

- DMSO supports efforts to digitize terrain from maps and then input that information into simulated battle scenarios. Such an effort can foster the development of common terrain data bases for cross-service use.
- DMSO supplements ongoing development of a DOD-wide telecommunications network called Defense Simulation Internet. This project was initiated by the Defense Advanced Research Projects Agency as a technology demonstration and is expected to facilitate joint training exercises by linking various war-gaming and simulation centers.

[2]The DMSO Director serves as Executive Secretary to the Executive Council for Modeling and Simulation, which is composed of senior-level officials from the services, Joint Staff, Office of the Secretary of Defense, and other defense agencies.

[3]The scope of this review did not extend to examining the modeling and simulation offices of the services to determine their effectiveness in bringing about a coordinated approach to simulation activities.

- DMSO supports technical workshops in which industry, government, and academia work to prepare standards that will govern the development of simulation systems throughout DOD.
- DMSO supports the development of a computerized clearing house of DOD-wide models and simulations that will include reports, correspondence, and software descriptions. Prototype software is expected to be developed within the next several months and data to be loaded afterwards. The system is not expected to be fully operational until 1994.
- DMSO funds Navy and Marine Corps efforts to link their tactical war-gaming systems to enhance simulated amphibious operations. DMSO has also supported the Army and the Air Force's efforts to link their war-gaming models. Likewise, the Navy and the Air Force are collaborating on a Joint Air Combat Training System.

Need for Long-Range Master Plan and Controls Over Simulation Development

In its May 1992 Defense Modeling and Simulation Initiative management plan, DMSO outlined its vision, goals, objectives, investment strategy, and future activities. In this plan, DMSO recognizes that DOD does not have a unified statement of modeling and simulation needs and deficiencies across DOD. DMSO highlights the need for (1) this assessment, (2) the development of a DOD-wide process to develop individual master plans for each of the DOD components, and (3) the implementation of a consolidated master plan that draws upon the individual plans. A requirement for individual service plans is included in the draft DOD directive on modeling and simulation. DMSO expects to complete an initial draft of a master plan in 1993, which will incorporate some of the services' views on the subject.

To help identify needs and deficiencies in the simulation area, DMSO conducted workshops with functional users (such as training and test and evaluation) from each of the services, the CINCs, defense agencies, and federally funded research and development centers. In March 1993, DMSO published the results of the workshops and envisions producing a similar report every 2 years. Further, DMSO expects to use this and other information to guide its priorities for funding projects to help address the deficiencies.

In its modeling and simulation initiatives plan, DMSO also recognizes the need to improve controls over the development and use of models and simulations. Two areas of particular concern are configuration management and the verification, validation, and accreditation of models. Problems with configuration management result when organizations

modify simulation system software without fully documenting changes. Lack of configuration control makes it difficult to ensure system reliability and validity.

Verification, validation, and accreditation are needed to ensure model reliability and consistency. Verification is the process of determining that models accurately represent the developer's conceptual description and specifications. Validation determines the extent to which models accurately represent the real world from the perspective of the intended users of the simulation. Accreditation is the determination that the model or simulation is acceptable for its intended purposes.

In beginning to address these issues, DMSO has included in a draft DOD directive on models and simulations a requirement that the services and other defense organizations assign responsibility for configuration control to a specific organization.[4] DMSO also has included in this draft directive a requirement that the services establish a verification, validation, and accreditation program. Further, the directive assigns responsibility to the services for accrediting simulations of their respective forces when they are included in models developed by another service.

DMSO Staffing and Funding

The Office of the Secretary of Defense expected DMSO to operate with a small staff and rely on interagency groups to accomplish its mission. The decision by the Deputy Secretary of Defense to create DMSO carried with it an expectation that DMSO staffing would be found within existing personnel levels—a challenging objective in the face of pressures to reduce personnel as part of ongoing DOD downsizing efforts.

DMSO lacks permanent personnel billets and operates with a temporary staff that has fluctuated in size from approximately six to eight government personnel on loan from the services. This staff is augmented by up to eight staff years of contractor support. The DMSO Director, Technical Director, and Budget Officer temporarily occupy some of the staff positions. However, temporary authorizations for the director's position expired in August 1992, and the authorization for the Budget Officer position expired at the end of calendar year 1992. Further, DMSO officials have been or are in the process of being reassigned. Moreover, DMSO officials have sought some permanent staffing authority for their office, but as of April 1993, they had not obtained formal approval. The

[4]This directive, currently being reviewed by the services, defense agencies, and Joint Staff organizations, is expected to be issued this fiscal year.

officials seek, for example, to fill a civilian senior executive position to provide a permanent director for the office. The absence of permanent staffing could create gaps in institutional knowledge and hamper mission continuity.

Although the Congress strongly supported DMSO by creating and initially funding it, internal DOD budget reviews have created uncertainty about future funding prospects. In fiscal year 1991, Congress appropriated $75 million for DMSO, but $50 million of that money was included in a DOD budget recision. The following year, Congress appropriated $50 million, approximately $20 million of which was lost through the DOD budget recision process. DMSO has a fiscal year 1993 congressional appropriation of $70 million. Table 2.1 summarizes DMSO funding from fiscal year 1991 through fiscal year 1993.

Table 2.1: DMSO Funding for Fiscal Years 1991-93

Dollars in millions

Fiscal year	Research and development	Procurement	Total appropriated	Total after DOD budget reclsions
1991	$15	$60	$75	$25
1992	40	10	50	30
1993	60	10	70	70[a]

[a]No recision action as of February 1993.

Overlapping Roles Between Joint Staff Directorates

The missions of DMSO and the Joint Staff are complementary, with both addressing some aspects of joint training. In contrast with DMSO, which is filling a broader mandate and more of an integrating role across the military services, the efforts of the Joint Staff focus on joint operational matters involving CINCs. However, within the Joint Staff, two directorates that we reviewed have unnecessarily overlapping responsibilities in providing simulation assistance to the CINCs, and each brings a different perspective on how to provide such support.

According to Joint Administrative Publication 1.1, August 1992, several Joint Staff directorates have responsibilities for various aspects of modeling and simulation. Two of these directorates, J-7 and J-8, have assigned responsibilities for supporting CINCs' training activities with computer simulations. For example, J-7 oversees operations of the Joint Warfare Center, a computer war-gaming center located at Hurlburt Field,

Florida.[5] This center, which until the late 1980s, had operated under the now defunct Readiness Command and subsequently under Forces Command, was instrumental in developing simulations and supporting joint exercises conducted by the unified and specified CINCs.[6] Further, in March 1992, J-7 established a Joint Simulation and Interoperability Division (JSID) and tasked it to coordinate modeling and simulation activities involving the CINCs. Specifically, the division's mission is to promote the application of models and simulations in joint operational planning and execution, education, training, exercises, operations requirements, joint test and evaluation, and doctrine development and evaluation. The division is expected to monitor service modeling and simulation programs and development activities to encourage joint applications within these areas.

At the same time, J-8 is tasked with developing joint modeling and simulation capabilities as necessary to support assigned missions, including conducting joint war games and interagency politico-military seminars and simulations. J-8's assigned missions were not changed with the creation of JSID. J-8's technical director said his organization has long been responsible for providing or arranging for simulation support to the CINCs across a broad spectrum of functions, including training, education, operational planning, and analysis. The technical director said this support is provided by his staff of over 80 operations research analysts and through agreements with the services' simulation experts, such as the Army's National Simulation Center. J-8 is also the focal point for the Joint Staff's Modern Aids to Planning Program through which CINCs obtained their own simulation hardware and software capabilities.

Officials in each of the Joint Staff directorates have voiced differing perspectives on how simulation support for CINCs should be provided. An area of long-standing concern to Congress has been the lack of a clear assessment of CINC simulation requirements. Both of the Joint Staff directorates claim some responsibility for completing this assessment. J-8 has surveyed CINCs to identify their current simulation capabilities and expected requirements for training, education, analysis, and operations support. The survey was undertaken to establish a baseline capability from

[5]The Joint Warfare Center is the only war-gaming center funded and operated under the Joint Staff. Other war-gaming centers are funded by an individual service, such as the Army's National Simulation Center in Fort Leavenworth, Kansas, or by multiple services, such as the Army/Air Force-funded Warrior Preparation Center in Germany. A 1989 DOD Inspector General Report recommended that the Joint Warfare Center be disestablished because it duplicated the simulation capabilities of other services.

[6]The Joint Warfare Center's mission was revised in May 1991 to delete any continuing role in the development of models and simulations. It now focuses primarily on supporting CINC joint exercises and training programs.

which an investment strategy and master plan could be developed. A report summarizing the questionnaire results was issued in October 1992. This report is the first of a three-volume report. A second volume is expected to discuss a strategy for meeting the identified needs, and a third volume is expected to outline an investment plan. The last two volumes are expected to be completed in 1993.

The JSID Director told us that the J-8 survey is heavily weighted toward analysis issues and hardware needs but does not fully address operational and training needs of the CINCs. Our review of the J-8 questionnaire summary indicated that CINC-identified simulation needs covered a broad spectrum of areas, including training, operations, education, and analysis.

In a separate effort, the J-7's Joint Warfare Center has begun soliciting information from the CINCs on the simulation requirements needed to participate in some advanced technology demonstrations. JSID officials said this inquiry responds to recommendations anticipated from a 1992 Defense Science Board Task Force.

When first established, JSID was concerned about duplication among the CINCs and had considered a process to have CINC training requirements funneled through it before steps could be taken to develop new simulations. The intent of such a proposed process was to ensure that requirements identified by one CINC would be reviewed by other CINCs to determine whether they had similar needs. Once the needs were determined, JSID had planned to work with the CINCs and the technical experts in J-8 and the Joint Warfare Center to identify the best way to meet all CINCs' needs.

The J-8 technical director told us that his division currently compares requirements of the various CINCs to minimize duplication where possible in meeting the needs and that he believes another process is not needed. However, some CINCs have expanded their own simulation capabilities independent of Joint Staff support. In some cases, CINCs obtain assistance from other simulation centers operated by the Army and Air Force. For example, during the recent exercises in Korea, staff from the Army's National Simulation Center, rather than the Joint Warfare Center, supported the CINC. Thus, at the present time, simulation support for CINC activities comes from multiple sources within and external to the Joint Staff.

According to the JSID Director, a central review process in JSID was not implemented, but the director believes more effort is needed to better integrate CINC training requirements for simulations with other functions. To this end, the Joint Staff initiated a study to assess whether a consolidated joint training, doctrine, and simulation center is needed. The first part, completed in February 1993, indicated a need to bring trainers together with developers of military doctrine and to bring both of these functions together with the developers of training tools, like simulations. The second part of the study, expected to be completed in July 1993, will determine the most appropriate structure for the center. Among other structures being considered is the consolidation of the existing Joint Warfare Center, the Joint Doctrine Center, and JSID.

In addition, two other efforts are underway that might eliminate some of the overlap. The Vice Director of the Joint Staff recently initiated a 2-month study of the organization and staffing of the Joint Staff. Because of downsizing in DOD, this study is intended to identify where additional staff can be eliminated, and one area of interest will be overlapping functions. Finally, the Chairman, in response to legislative requirements, is conducting a comprehensive study of the roles and missions of the armed forces. One area being considered is an integrated training and test and evaluation structure that will electronically link the services' training and test ranges in six western states. This structure is expected to provide a land, airspace, sea area, and offshore supersonic operating domain to accommodate a large portion of joint training and test and evaluation needs.

Conclusions

A DOD-wide structure for providing oversight and guidance regarding simulation technology is in place, and progress is underway in key areas. DMSO has provided an important focal point for the simulation initiative but has yet to complete a master plan for meeting identified needs and deficiencies or ensure adequate controls over simulation development. Continued progress could be adversely affected by a lack of permanent staffing for the office. Despite progress made at DMSO, much remains to be done to sort out the roles and responsibilities of the Joint Staff, particularly between J-7 and J-8 in the simulation area. Three studies are underway or anticipated that may help resolve the inefficient use of resources that now exists and better address simulation support for the CINCs.

Recommendations

We recommend that the Secretary of Defense

- ensure that DMSO is properly staffed to carry out its assigned responsibilities and
- eliminate unnecessary inefficiencies within the two Joint Staff directorates involved in simulations and more clearly delineate each directorate's roles and responsibilities in this area.

Agency Comments and Our Evaluation

In commenting on a draft of this report, DOD concurred with our recommendation to properly staff DMSO and partially concurred with our recommendation to eliminate duplication within the Joint Staff. DOD said that responsibilities for modeling and simulation functions were shared by several directorates, not just those included in this report. DOD said that this does not constitute unnecessary duplication or overlap of effort. DOD's comments are presented in their entirety in appendix II.

Since we found overlapping functions between two joint staff directorates, especially with respect to identifying modeling and simulation requirements for CINCs, which resulted in inefficient use of resources, DOD's acknowledgement that even more joint staff directorates have modeling and simulation responsibilities does not dispel our concern, but rather serves to reinforce it. Moreover, for DOD to express the opinion that there is no unnecessary duplication before its own studies of the issue are completed seems to undermine the purpose of the studies.

Army Acts to Strengthen Simulation Management and Ensure System Interoperability

Responding to congressional concerns about the management of CCTT and CATT acquisitions, the Army formulated a plan to ensure that these systems would have high-level oversight comparable to that provided for major weapon system acquisitions. The Army also strengthened its management structure for acquiring simulations. The revised structure is intended to elevate acquisition decisions to a higher level and to ensure more direct involvement of the Army Acquisition Executive—a role filled by the Assistant Secretary of the Army for Research, Development, and Acquisition. These actions affect the acquisition of CCTT and other simulation systems. In addition, the Army also has taken steps to ensure interoperability between CCTT and follow-on CATT systems, and other simulations.

CCTT and Other CATT Components to Be Acquired as Major Systems

In November 1991, the Army developed a master plan to outline the management structure for acquiring the CCTT and other simulations in the CATT system. The master plan stated that the CATT system will be a series of unique training devices for each of the Army's combat forces (armor, aviation, air defense, and artillery, for example). While these training devices—called CATT components—will be developed with the capability to electronically link together, each device, according to Army officials, is a complete stand-alone training system that can be operated independently of other components. This approach seems consistent with the DIS concept, which is based on systematically linking numerous operational subcomponents to create a larger system.

Because of its estimated cost in excess of $1 billion and high visibility, the CCTT was designated as a category II major defense acquisition program.[1] Such a designation requires the Army Acquisition Executive to approve key acquisition decisions following milestone reviews by the Army Systems Acquisition Review Council.[2] Analytical evidence must be presented at these milestone reviews to justify continuing the program and ensure that the program meets specific requirements in the test and evaluation area. Appendix I contains an overview of milestone review requirements, and table 3.1 shows CCTT's milestones and other key dates.

[1]Category II programs have research, development, test, and evaluation expenditures of $115 million or more or a procurement expenditure of $640 million or more (in 1990 dollars). These programs must be approved by an official no lower than the Acquisition Executive for the specific DOD component.

[2]The members of this council include top managers from a broad spectrum of Army organizations, such as the Assistant Secretaries for Financial Management and Research, Development, and Acquisition; various Chiefs of Staff and their deputies; officials from the training and testing communities; and others.

Since much of CCTT's conceptual development had been accomplished under SIMNET, two of the normal reviews were combined.

Table 3.1: CCTT Milestones as of December 1992

Milestone	Date	Activity
0	Under SIMNET	Concept explored and demonstrated
I/II	June 1991	Preliminary approval of engineering and manufacturing development
I/II	Oct. 1991	Final approval of development
—	Nov. 1992	Contract award
—	Sept. 1994	Deadline for software critical design review
—	Oct. 1995	Deadline for detailed test and evaluation plan
—	May 1996	Begin fielding limited-capability units
—	Dec. 1996	Begin initial operational test and evaluation
III A	Apr. 1997	Decide low-rate of initial production
III B	Dec. 1997	Decide full-rate of production
—	Aug. 1998	First system delivered
IV	Not determined	Upgrades and improvements

To expedite the production and fielding of CCTT, the Army currently plans to divide its milestone III decision into two parts—the first for a low rate of initial production and the second for full production. Army officials hope to have sufficient testing data by the milestone III A decision point to authorize a low rate of production while awaiting final compilation and printing of test results for the milestone III B full-production review.

Like CCTT, each follow-on CATT component is expected to be acquired as a major, separate, stand-alone system with funding budgeted as a separate program line item. CCTT funding through fiscal year 1993 has been included in the Army's overall funding line for training devices. Separate line item funding for CCTT is planned for fiscal year 1994 and beyond and for each subsequent CATT component.

The Army awarded a contract to the International Business Machines Corporation on November 30, 1992, to begin engineering and

manufacturing design of the CCTT.[3] The contract is valued over $409 million and covers the development of 49 CCTT prototypes to be used for testing and the production of 68 limited-capability units.

New Command to Manage the Acquisition of Simulations

Until recently, the Army Material Command's Project Manager for Training Devices in Orlando, Florida, was responsible for helping Army components define user requirements for a wide range of training devices and simulations and for managing related acquisitions.[4] In the case of CCTT, the Project Manager for Training Devices worked with the Army's Armor School at Fort Knox, Kentucky, to develop system requirements. In August 1992, the Army created a new major subordinate command known as the Simulation, Training, and Instrumentation Command to centralize oversight of technology development and life-cycle support for training devices; Instrumentation, Targets, and Threat Simulations; and other Army battlefield simulations.

This new structure is intended to assign higher level attention to day-to-day program management responsibility over CCTT and is designed to provide more direct lines of communication with the Army's Acquisition Executive in major decisions affecting CATT components. The Army also appointed a separate Project Manager for CATT to manage the development and fielding of CCTT and other CATT systems.

Other CATT Components to Follow Same Process as CCTT

Future CATT component acquisitions are expected to follow the same acquisition process as CCTT. Acquisition milestones for other CATT systems are undecided for now; however, requirements documentation and reviews are further along for the aviation trainer than for the other systems. We were told that in an era of declining defense resources, CCTT is currently a high priority among senior Army leaders. Less clear is the degree of funding support for other CATT systems in relation to competing acquisition systems.

[3]The Army's contract award for CCTT was delayed 2 months beyond the expected award date because of concern on the part of Army officials, particularly the Army's Acquisition Executive, about cost realism of individual, competing firms. After discussions between the Acquisition Executive and representatives of the competing firms, the firms raised their cost proposals in varying amounts so that they were much closer to the Army's valuation of the likely costs.

[4]This Project Manager is co-located with the Naval Training Systems Center, which provides the Army with technical contracting assistance in acquiring training devices and simulations.

Steps to Ensure Interoperability Among CATT Components

The Army has taken steps to ensure interoperability and compatibility among CATT components by mandating the use of DOD's standard military programming language and by requiring an open design in which interfaces between hardware and software do not depend on vendor-specific or proprietary equipment. The Army expects these steps to facilitate upgrades and make interoperability between CATT and other future simulation systems possible. Moreover, according to DOD officials, the Army is taking a leadership role in pursuing the development of standards to govern future Army and DOD simulations and ensure their interoperability.

Conclusions

The Army has acted to ensure high-level executive oversight of CCTT and involvement in key milestone decisions. It has also reorganized and elevated the management of the CCTT program. Further, the Army has included requirements in the CATT master plan and the CCTT specifications to ensure interoperability among simulation systems.

Army Accelerates CCTT Acquisition Without Validated Data on Performance, Cost, or Integration Capabilities

The Army is integrating simulation technology with traditional field training programs; however, the question of what is the most cost-effective mix of field and simulation training has not been quantified. Until the Army completes operational testing and cost-effectiveness assessments (expected in 1996), the most efficient and effective mix of CCTT and traditional training will not be known. Pressures from some Army commanders to accelerate fielding of CCTT have led to plans to field 68 limited-capability units in Germany and the United States before the completion of operational testing. Differences of opinion exist over how quickly the full system can or should be developed and fielded. However, our review indicated that shortening the acquisition process to accelerate system development and fielding could have several important drawbacks.

Lack of Validated Data on Mix of Simulations and Field Training

The Army is developing a combined arms training strategy to help manage its training resources in a more integrated manner. When completed, this strategy is intended to establish a definitive relationship between the mix of field and simulation training. However, the strategy is still evolving, and it is not clear when definitive data will be available to provide precise answers to questions about the most appropriate mix of field and simulation training or the best combination of CATT systems. This issue is further affected by decisions to reduce the planned sets of CCTT to be acquired and the echelon on which training will be focused.

Combined Arms Training Strategy to Help Manage Training Resources

Since 1988, the Army has been working toward developing a strategy to better identify the training requirements of its total force (armor, infantry, aviation, etc.); a strategy that will enable it to manage all training in an integrated manner. The Army intends for this strategy to provide guidance on how to efficiently mix simulation capabilities with more traditional field training—simply stated, the "right mix." By showing training events to be conducted, frequencies, and resources needed to conduct those events, the Army believes that a combined arms training strategy could help measure the relative value of each resource needed to train to standard. Because the standard remains constant, the strategy is expected to clarify where changes in resources will impact training and allow decisions on trade-offs.

At the heart of the Combined Arms Training Strategy is a series of individual training strategies to be developed by the Army's training centers and schools. The strategies are expected to identify the best mix of field exercises and simulations and ensure that the effectiveness of

simulators is determined before critical acquisition decisions are made. As of January 1993, only coordinating drafts of the strategy from various doctrinal schools had been prepared. The Armor Strategy, which relates to training involving the CCTT, contains only tentative data (that is not validated by user testing) regarding the right mix between CCTT and field training.

Uncertainties Over Use of CCTT Simulators and How Best to Integrate Them With Field Training

The Army has estimated that a total of 546 CCTT units will be needed to train the active and reserve armor units at the echelons of company level and below.[1] Table 4.1 summarizes the quantities and the delivery schedule for the CCTT. In determining the desired quantities of CCTT units and follow-on CATT systems, the Army considered the expected future force structure, the draft armor training strategy, and information from a 1989 review of annual training plans for armor and mechanized infantry units.

Table 4.1: Planned Quantities and Deliveries of CCTT Units

Number of units	Type of unit	Initial delivery dates
68	Limited capability in fixed sites	May 1996
38	Fixed-site testing prototypes	Oct. 1996
11	Mobile testing prototypes	Jan. 1997
326	Full capability in fixed sites	Oct. 1998
103	Full capability mobiles	July 1999
546	**(432 in fixed sites and 114 mobiles)**	

Training staff determined that approximately 20 days a year could be devoted to training with CCTT, providing trade-offs were made with other scheduled activities. Thus, the CCTT acquisition plan incorporates the idea of active duty company-sized units spending 20 days per year training with CCTT and 23 days training in the field. The plan assumes that reserve units will train using mobile CCTT units once or twice a year for a total of 4 to 6 days per year. Army officials recognize that their numbers are tentative and must be validated through user testing. Key questions to be answered through user testing include the following: (1) How long and at what intervals should units train on CCTT? (2) To what extent should CCTT be used as a prerequisite to certain field exercises? and (3) To what extent should CCTT be used to reinforce or sustain skills previously acquired?

[1]The term "echelon" refers to a level of command. Platoon, company, battalion, brigade, and division are succeedingly higher echelons of command.

In developing its acquisition plan, the Army decided to configure over 20 percent of total CCTT units in mobile sites although it did not have experience with mobile units to provide a more informed basis for its decision. Mobile SIMNET units were not placed in the inventory until July 1991, and an evaluation of mobile site experience is not anticipated until early 1994.

The Army estimated that training in other CATT components should be available to active duty company size units between 12 and 25 days per year and reserve units should have access between 2 and 4 days every year. The Army estimated quantities for CATT systems based on these frequencies, and like CCTT, these estimates are theoretical. The frequencies and quantities were not based on validated assessments of the training effectiveness of specific simulations because none of the CATT systems currently exists. The Army recognizes that the most appropriate mix between field training days and simulation time for other CATT systems is still subject to validation.

Changes in Training Focus and the Combination of CATT Systems

During the early stages of developing the CATT concept, the Army anticipated that the simulations would provide tactical training for battalion levels and below by networking sites from remote locations using long-haul networks. It initially planned to acquire up to 2,754 units. Since that time, the Army has lowered the training focus to company and platoon level using local area networks and reduced the number of CCTT units to 546. (Battalion sizes and long-haul networks are listed as potential system upgrades in the future.) Part of the rationale for this change is cost related, but it also includes a realization that the amount of networking needed is unknown since unanswered questions exist about how often the various elements of the combined forces above the company level would or should train together.

However, battalion-level tactical training needs can be partially met using the CCTT's semi-automated forces workstations to simulate additional forces—friendly or opposing. Further, at echelons of battalion and above, where there is increasing emphasis on command and control, much training can be provided through other computer-simulated, war-gaming exercises. Additionally, DOD is working on capabilities that would enable these war-gaming simulations to be linked with exercises conducted in systems such as CCTT and those from other services and with field training.

The most appropriate combination of CATT systems is unclear at this time because the Army does not know how often CCTT and other systems will be used independently or networked at higher echelons and because it has yet to validate the affordability of other CATT components.

The most appropriate mix between simulation and traditional field training is addressed in this report primarily as it relates to the Army's CCTT. However, as other services increase their use of simulation networking technology, the "right mix" issue will also confront them.

Uncertainty About CCTT's Cost

The Army System Acquisition Review Council tentatively approved CCTT's engineering and manufacturing development phase at the June 1991 combined milestone I/II review, in part, on the basis of a preliminary cost and training effectiveness analysis. Army officials recognized that the data used in this analysis were "soft" and would need to be validated. The preliminary analysis concluded that CCTT could be a cost-effective addition to the Army's training program but recommended that savings associated with CCTT be quantitatively validated based on the results of user testing. The review council's approval also stated that potential reductions in training resources due to the CCTT must be validated by test results and not based on artificial numbers.

The preliminary cost and training effectiveness analysis was performed by analysts from the Training and Doctrine Analysis Command at White Sands Missile Range, New Mexico, in May 1991. The analysis was based upon existing assessments of benefits associated with CCTT's predecessor system, estimated training data from the Armor School, and total life-cycle costs then estimated at $1.2 billion for 546 units with 65 percent of the cost attributable to the active component and 35 percent to the reserves.[2] The analysis concluded that the active component portion of the costs could be fully paid back during the 15-year service life if the active duty units could trade off about 8 percent of their field training resources. The reserve units would have to trade off nearly 16 percent of their training resources to break even within the same period. These trade-offs were estimated without frequency data from the reserves.

Alternately, the preliminary analysis indicated that by increasing the active duty trade-offs to nearly 14 percent, the active component could pay for its share of the system cost and, after the 15-year system life, accumulate an

[2]The CCTT development contract value is slightly over $409 million. Program officials estimate that the 15-year life-cycle cost will be about $1.3 billion, much of which is operational sustainment costs.

estimated savings of $771 million—an amount sufficient to cover the $410-million cost to produce the units to train the reserves. The study further indicated that any increase in CCTT life-cycle costs would require further trade-offs in traditional field training resources to pay back the costs. The study cautioned that the extent of any payback would have to be validated based on the results of user testing.

Uncertainty over the Army's initial cost analysis was affirmed by the use of substantially different dollar amounts in an internal affordability briefing prepared for the Army Acquisition Executive in July 1991—1 month after the milestone I/II review. Information provided in that briefing showed that the life-cycle cost estimate was nearly 50 percent higher than the one used in the preliminary analysis. Army officials attributed part of the higher costs to uncertain estimates of sustainment costs.

While the reliability of cost data in the preliminary analysis is questionable, documentation associated with that analysis indicates the Army's intent to assess the feasibility of offsetting costs of the CCTT through reduced field training funds in the future. Further, the Army Acquisition Executive in his milestone I/II approval memorandum stated that the Army was committed to identifying specific field training costs reductions that are made possible by the introduction of the CCTT system. The Army Acquisition Executive also stated that, where practicable, the savings resulting from such reductions will be used to offset the costs of developing and fielding a CATT program and to expand the company level capability of CCTT to the battalion level.

Program officials cautioned, however, that the Army has not decided how much of its field training resources it is willing to give up to pay for the CCTT and remained firm that any trade-offs should begin only after the system is in the field. (The system is currently scheduled to be fielded in August 1998.) This uncertainty reinforces the importance of operational testing as a tool for providing important insights into CCTT's cost and training effectiveness before the milestone III review.

The preliminary cost analysis indicated that the active component costs could be repaid over the CCTT's life cycle, but, according to the Army's cost analyst, the estimated costs of preplanned product improvements were not included in the analysis. These preplanned improvements are the desired features that program managers perceived as too expensive to include in the basic system or those that could not be technologically produced at the time. They include simulation for such features as electronic warfare;

nuclear, biological, and chemical effects; dynamic terrain;[3] long-haul networks; and battalion sets. They also include additional modules to simulate the armored combat earthmover and the air defense antitank system.

Although the documents we reviewed identified these improvements, their costs were not estimated. One Army official involved with the CCTT acquisition said these preplanned improvements should be discussed during the milestone III review to fully disclose the potential system costs; while another official said they need not be discussed then. This second official said each improvement should be reviewed separately as it is developed.

Testing Is Critical for Assessing Cost and Training Effectiveness

Although the CCTT acquisition plan requires operational testing to be complete prior to the milestone III full-rate production decision, some questions exist about whether testing will be completed as planned. An October 16, 1991, CCTT Test and Evaluation Master Plan outlines two types of required tests: technical and user. The technical tests are needed to determine whether CCTT's design is adequate for the required mission and whether it meets system requirements. User tests are needed to evaluate the effectiveness of CCTT as a training tool and determine its effect on mission performance.

Technical Tests

Technical tests are scheduled to be performed over a period of about 14 months (beginning in July 1995) by both the contractor and the government. Testing will ensure that system requirements are met and will include, but are not limited to, the following areas:

- CCTT's capability to replicate a battlefield for conducting combined arms missions, including the representation of different types of simulators, semi-automated friendly and opposing forces, command and control work stations, various types of terrain, and acceptable graphics;
- the degree of fidelity or realism of soldier-machine interfaces necessary to simulate actual combat conditions;
- the extent to which safety and health hazards associated with operating or maintaining the system have been controlled such that any action that

[3]Dynamic terrain involves the simulation of changes in the ground or terrain as ditches are dug to provide cover for tanks, or craters are created from the effects of artillery fire. Dynamic terrain remains an area of great technical challenge that has the potential to add significantly to training capabilities.

might cause injury with the real equipment will be simulated or identified as a possible safety hazard; and

- CCTT's compliance with the established requirements for reliability, availability, and maintainability such that system failures are kept to a minimum and repairs can be accomplished within an acceptable time frame.

The technical tests will also include an independent verification and validation of the software by the Army's Communications-Electronics Command's Center for Software Engineering to ensure the clarity, completeness, consistency, and traceability of the software to the system requirements. The Project Manager for CATT will be responsible for seeing that the verification and validation is performed concurrently with the software development.

According to Army officials, performing the verification and validation concurrent with the software development should help identify potential technical problems with CCTT and outline solutions before the system is completed. This approach is consistent with a recommendation by the Army's Test and Evaluation Command in its 1991 assessment of CCTT risks.

User Tests

User tests are currently scheduled to be performed at Fort Hood, Texas, beginning in December 1996. This testing is intended to evaluate training effectiveness through a series of company-sized field experiments for tank and mechanized infantry units.[4] Units will undergo pre-training evaluations, training, and post-training evaluations that include similar situational exercises. Between evaluations each test group will undergo similar training treatments designed to evaluate the contribution of CCTT training to combat effectiveness and survivability. One group will receive no training and will serve as a control.

The training groups and mix of training, as summarized in table 4.2, will include various mixes of traditional field training and CCTT simulation training as outlined in the October 1991 Test and Evaluation Master Plan.[5]

[4]Training effectiveness is a quantitative measure of how much one's exposure to a certain training device will improve or hinder performance. This measure contrasts with training transfer, which observes whether training positively or negatively affects how one performs tasks, but does not measure the degree of change quantitatively.

[5]Army officials told us in December 1992 that they are examining ways of streamlining various aspects of the planned user tests to control costs and expedite system fielding. However, the extent of those changes and their impact on assessments of training effectiveness are unclear for now.

A detailed plan linking the functions to be tested with the test scenarios is scheduled to be completed and approved by October 1995.

Table 4.2: Training Mix for CCTT Operational Tests

Training group	Training mix
1	Traditional field training
2	2 days CCTT; 8 days traditional field training
3	4 days CCTT; 6 days traditional field training
4	6 days CCTT; 4 days traditional field training
5	No training (control group)

Our review of the master test plan indicated that the user testing section is more comprehensive than prior SIMNET evaluation plans. The proposals for SIMNET field tests and reports we reviewed indicated that those tests were generally subjective; control groups were not used; and the tests, when conducted, were conducted within short time frames. In one instance, the SIMNET tests were not conducted as planned because of high costs and the unavailability of a test site. Although SIMNET was assessed as providing a positive training benefit, its training effectiveness was never quantified. That limitation inhibited the potential for (1) measuring the extent of training effectiveness of this type of simulation relative to traditional field training and (2) defining the contribution of each to the most appropriate mix issue. By contrast, CCTT tests are designed to measure training effectiveness and determine the value of this type of simulation compared to traditional field training.

The 1991 CCTT Test and Evaluation Master Plan estimated that about $15 million will be needed to complete the technical and user tests. Estimates provided by Army officials in December 1992 indicated the costs should be less than $19 million.

According to DOD, the CCTT training effectiveness evaluation, as currently envisioned, will be the most comprehensive and expensive ever devised in DOD. However, none of the training mixes includes a CCTT-only scenario, contrasted with a field training-only scenario. DOD believes that it is not needed because CCTT is not designed as a replacement for field training. Nevertheless, such a comparison might give even greater insight into the training benefit of simulations compared with more traditional forms of training.

Production of Some CCTT Units Before Testing and Production Decision

Because of pressures within the Army to have simulation training capabilities greater than those available through SIMNET, the Army decided to field in Germany and the United States 68 limited-capability "Quick Start" CCTT units in advance of system testing and a production decision.[6] Thus, these units will be fielded more than 2 years earlier than full capability units and about 7 months before the planned initiation of operational testing.

The acting Program Manager and the Training and Doctrine Command's System Manager said they believe Quick Start was a good way to get improved training capabilities into the field quickly. They indicated that some testing of Quick Start units would be done to ensure compliance with technical specifications. Although the original testing plan did not include assessments of training effectiveness for the Quick Start units, we were told that the Army now plans to incorporate such tests.

Caution in Accelerated Development and Fielding

Differences of opinion exist within the Army concerning the prospects for further accelerating CCTT development and production. Some Army officials believe that the acquisition could and should be accelerated; others point to significant, and time-consuming development activities yet required, such as producing over 600,000 lines of computer programming code. A program official told us that one way to accelerate the program would be to reduce the time allocated for testing. In December 1992, Army officials told us that they were discussing ways to accomplish earlier and more constrained testing to help expedite system fielding.

We have reported extensively on the importance of conducting operational tests and evaluations prior to beginning full-rate production.[7] Failure to do so can result in higher program costs, future scheduling delays due to the need to make system modifications, and performance problems.

[6]The Quick Start units will be degraded versions of the CCTT, relying on SIMNET's communications capabilities and data base. Quick Start units will be able to operate in a stand-alone mode or with SIMNET simulators to incorporate SIMNET's semi-automated forces. The full production CCTT units will have significant upgrades of all of these features requiring extensive software development. Quick Start, as well as final production CCTT units, will provide tank commanders with a capability lacking and much criticized for its absence in SIMNET—a simulated popped hatch providing the commander a 360-degree view of the battlefield as though he were able to look at the battlefield from an open hatch on the top of the tank. Quick Start will include only the M1A1 tank and Bradley Fighting Vehicle; the full-production CCTT units will simulate additional vehicles.

[7]Army's M109 Howitzer: Required Testing Should Be Completed Before Full-Rate Production (GAO/NSIAD-92-44, Jan. 23, 1992) and Weapons Testing: DOD Needs to Plan and Conduct More Timely Operational Tests and Evaluations (GAO-NSIAD-90-107, May 17, 1990). This report also lists additional GAO reports on this subject.

Conclusions

The Army is working toward developing a strategy to integrate CCTT and other CATT systems with traditional field training. However, the lack of data on system cost and quantitative assessments of how much each system can be expected to contribute to overall training precludes a definitive answer at this time on CCTT's expected cost-effectiveness and on the most cost-effective mix of CATT systems that will be needed. This uncertainty makes complete performance testing and cost and training effectiveness analysis even more important. Pressures to further accelerate CCTT development and production could prompt the Army to shortcut required testing and analyses before making full production decisions. However, shortcutting these critical reviews could limit (1) full disclosure of future program costs for the CCTT, including possible costs of preplanned product improvements; (2) the Army's ability to more definitively assess the effectiveness of this system and its contribution to the right mix issue; and (3) insight into potential trade-offs between simulations and resources required for traditional field training.

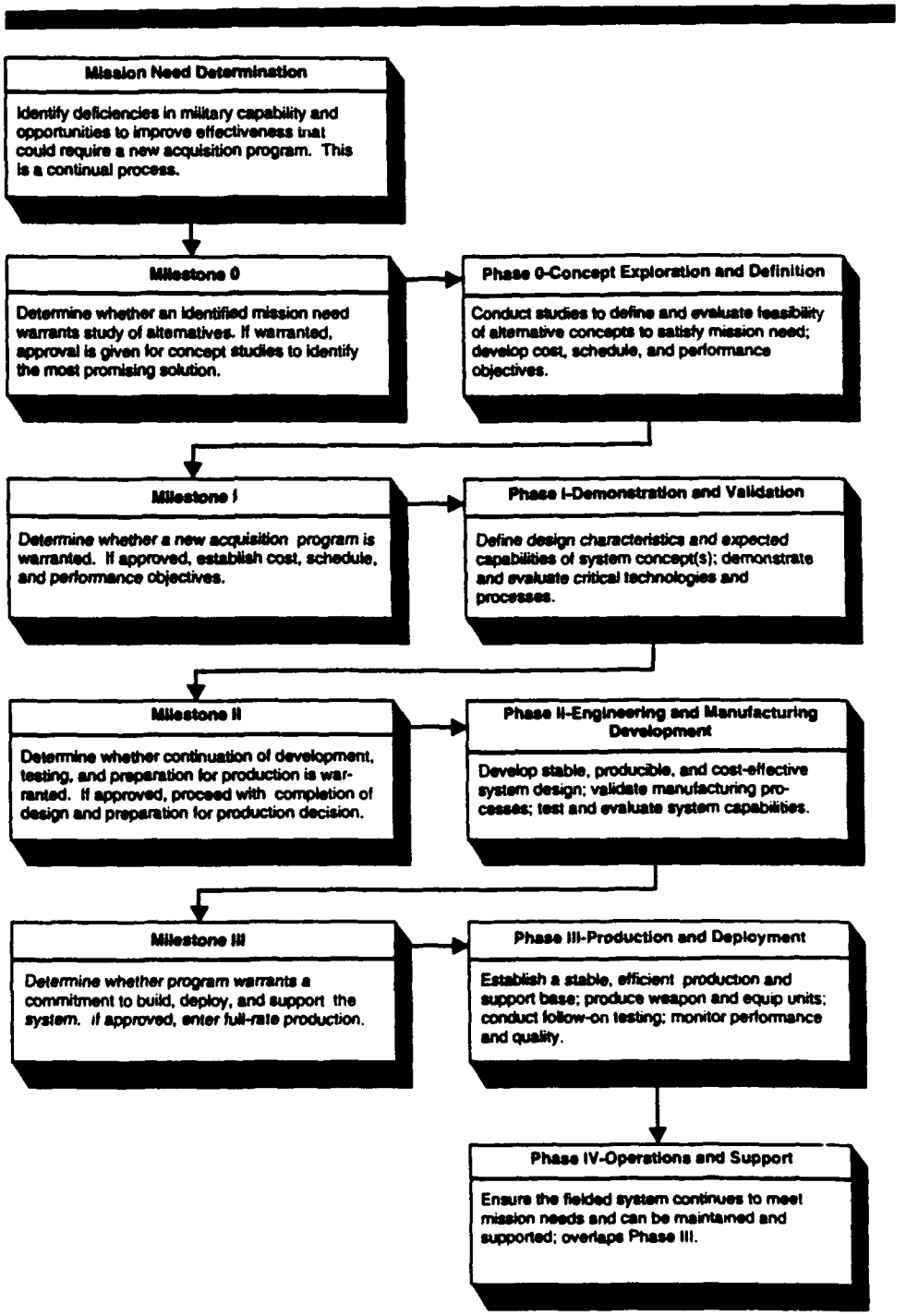
Recommendation

We recommend the Secretary of the Army ensure that all prerequisite testing, cost analyses, and training effectiveness assessments are completed and fully considered before decisions are made about the full-rate production of the CCTT.

Agency Comments

DOD concurred with our recommendation. It noted that of the two types of required testing (technical and operational), technical testing is straight forward and can be executed using established techniques. DOD noted, however, that operational testing includes an unprecedented critical issue on training transfer. Methodology must be developed to determine training transfer in a combined arms environment because of the myriad of variables involved in combined arms operations.

Overview of DOD's Systems Acquisition Milestones



Note: A fourth milestone may be necessary to determine whether significant upgrades are needed for the weapon in production

Comments From the Department of Defense

Note: GAO comments supplementing those in the report text appear at the end of this appendix.

OFFICE OF THE DIRECTOR OF
DEFENSE RESEARCH AND ENGINEERING

WASHINGTON, DC 20301

MAR 26 [illegible]

Mr. Frank C. Conahan
Assistant Comptroller General
National Security and International
Affairs Division
U.S. General Accounting Office
Washington, D.C. 20548

Dear Mr. Conahan:

This is the Department of Defense (DoD) response to the General Accounting Office draft report "DoD AND ARMY SIMULATION TRAINING: Management Framework Improved, But Challenges Remain", dated February 4, 1993 (GAO Code 391173/OSD Case 9319). The DoD concurs with the majority of the findings and recommendations.

The DoD only partially concurs with the findings on replacing simulation networking with the Close Combat Tactical Trainer, the overlapping roles between the Joint Staff Offices, and the critical testing for assessing cost and training effectiveness. The DoD also only partially concurs with the recommendation that the Secretary of Defense eliminate the duplication and simulation inefficiencies within the two Joint Staff directorates involved in simulations and clearly delineate each directorate's role and responsibilities in this area.

The Joint Staff manages modeling and simulation activities as an integral part of its Information Resources Management program. Specific modeling and simulation responsibility/proponency are assigned in accordance with each directorate's function. The Deputy Director for Technical Operations is responsible for coordination of oversight, planning, and management of modeling and simulation technology for the Joint Staff. Studies are currently underway to clarify the use and application of modeling and simulation. Results of those studies are expected by June 1993.

The detailed DoD comments on the recommendations and on each finding are provided in the enclosure. The DoD appreciates the opportunity to comment on the draft report.

Sincerely,

John M. Bachkosky
Deputy Director,
Defense Research and
Engineering

Enclosure

GENERAL ACCOUNTING OFFICE DRAFT REPORT
DATED FEBRUARY 4, 1993
(GAO CODE 391173) OSD CASE 9319

"DOD AND ARMY SIMULATION TRAINING:
MANAGEMENT FRAMEWORK IMPROVED, BUT CHALLENGES REMAIN"

DEPARTMENT OF DEFENSE COMMENTS

* * * * *

FINDINGS

• **FINDING A: Training Devices and Simulations.** The GAO reported that the Military Services traditionally have used hundreds of training aids and devices to model or simulate various aspects of combat, weapon systems, and terrain in support of training activities. The GAO found that computer simulations are growing in importance as training devices, because they are able to add realism to training and potentially reduce training costs.

The GAO observed that the DoD categorizes simulations into the following three classes on the basis of their technical and physical structure:

- Computer Simulation Models--Models provide a view of the battle on a map, which is displayed on a video monitor with units on the map shown as icons (unit symbols). War games fall into this category.

- Weapon system simulators--Simulators replicate the performance characteristics and appearance of a weapon system to help teach individual skills.

- Instrumented exercises--Actual troops, weapon systems, and support systems interact in as real an environment as possible, short of combat. (pp. 11-13/GAO Draft Report)

Now on pp. 8-9.

DOD RESPONSE: Concur. The definition used to describe weapons system simulators should also describe crew modules being used as crew trainers (simulators) and as platoon/company trainers (simulations).

See comment 1.

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Now on pp. 9-10.

See comment 2.

See comment 3.

• **FINDING B: Benefits of Simulation Training.** The GAO found that, while computer simulations have limitations, they also provide important training opportunities and capabilities not always feasible in traditional field exercises. The GAO explained that computer simulated exercises permit more concentrated and repetitive training for tactical operations -- such as tank maneuvers for ground forces--as well as command and control operations for leaders and their staffs. Moreover, the GAO noted that computer simulated training provides opportunities for individuals and units to enhance their skill levels before and after participating in traditional field exercises. Finally, the GAO observed, simulations permit training that is not otherwise practical in peacetime--such as the use of electronic warfare or emergency operations that might be restricted due to safety and environmental factors. The GAO pointed out, for example, that simulations played a key role in preparing U.S. forces for ground operations in Operation Desert Storm. The GAO concluded, however, that a key unanswered question is what is the most appropriate mix of each type of training. (pp. 13-15/GAO Draft Report)

DOD RESPONSE: Concur. It should be recognized, however, that the DoD does not use simulations solely for training devices. The devices are also used as a means to actually rehearse future combat operations in a realistic environment, prior to the first shot being fired.

The Army's Combined Arms Training Strategy should also be considered. The Department recognizes the variables of training (time, operating tempo, ammunition, training devices, ranges and land availability) to create an environment where there is a need to establish a descriptive training policy versus a prescriptive training policy. The Combined Arms Training Strategy program spells out a descriptive program for trainers, both for today and tomorrow, and assists in capturing future simulation requirements. The "appropriate mix" of training sought by the GAO will be captured by the Combined Arms Training Strategy program.

• **FINDING C: Simulation Networking--A Breakthrough Technology.** The GAO reported that, since 1983, the Defense Advanced Research Projects Agency and the Army have jointly pursued a project to develop technology for constructing large-scale computer networks to create a battlefield environment where combat teams and their related support

elements could operate together on a regular basis. The GAO observed the $200-million effort led to the creation of a training system that came to be called Simulation Networking. The GAO noted that, in Simulation Networking, numerous computer-driven simulators (configured around a mockup of the interior of an armored vehicle) are electronically linked to form a common combat arena or battlefield.

The GAO explained that Simulation Networking also incorporates some battlefield participants that are generated by the computer. The GAO observed that the participants are called semi-automated forces because a trainer initiates a combat task from a computer workstation, but the task is performed automatically according to specified war-fighting doctrine and tactics programmed into the system. The GAO noted that Simulation Networking also has a built-in data collection and analysis system, which records a complete history of a simulated battle--including (1) orders to take actions, (2) the resulting actions, and (3) the impact of the actions.

The GAO reported that Simulation Networking was first demonstrated in May 1986, at the Army's Armor Center in Fort Knox, Kentucky. The GAO noted that, ultimately, a total of 236 simulators were acquired and placed in eleven sites in the United States and Germany, where they have remained in continual use as a training device. The GAO pointed out that Army forces used Simulation Networking to prepare for Operation Desert Storm.

The GAO indicated that the success of the Simulation Networking program has led to the formalization of the networking protocols as an industry standard known as Distributive Interactive Simulation standards. The GAO noted that the Distributive Interactive Simulation concept has been expanded into several other Service-specific and DoD-wide initiatives. The GAO noted, for example, that Air Force Special Operations are developing a distributive interactive simulation-based air crew training system that will allow multiple aircraft to interact in a simulated battle.

The GAO reported that several studies undertaken by the Army Training and Doctrine Command to assess the Simulation Networking training benefit found the following limitations:

- only two major combat vehicles were represented;

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Now on pp. 10-13.

See comment 1.

- vehicle movements were not impeded by trees, rivers, or buildings, and vehicle drivers received no meaningful speed cues from the terrain;

- fields of view from the video monitors were smaller than in actual vehicles, and the gunnery systems were unable to identify targets at realistic distances; and

- the Commanders' view of the battlefield was constrained.

In addition, the GAO reported that an independent assessment of the Simulation Networking software by a systems engineering company also found many technical errors in computer code written to depict system performance. (pp. 15-20/GAO Draft Report)

DOD RESPONSE: Concur. The reference to the Air Force use of the Distributive Interactive Simulation standard for Special Operations is, however, over stated. The Department has directed the Air Force and the Special Operations Command to use the Distributive Interactive Simulation but, because the Distributive Interactive Simulation standard is relatively immature, and lacks a standard set of dead reckoning algorithms for fast movers, it is likely this will be done as a modification at a later date.

As a result of the Army experience in Simulator Networking and the subsequent leadership in the Distributive Interactive Simulation standard, the Army has participated in international simulation forums. That participation has led to the writing of Standard Agreements to establish the Distributive Interactive Simulation standard as an international military standard.

In the GAO discussion on the limitations of Simulator Networking, references were made to the number of vehicles and vehicle movement. For the number of vehicles, a more accurate statement would be "only two major ground combat vehicles were represented." Attack Helicopters and A-10 Thunderbolt aircraft were also networked during the proof of principle tests. When impediments were discussed, the GAO states buildings and rivers did not halt combat vehicles. That is not a correct statement.

• **FINDING D: Replacing Simulation Networking with Close Combat Tactical Trainer.** The GAO observed that, even before assuming full responsibility for Simulation Networking in 1990

from the Defense Advanced Research Projects Agency, the Army was already addressing Simulation Networking deficiencies. The GAO noted that the Army wanted to develop a family of advanced simulators to train all of its forces under an umbrella concept known as the Combined Arms Tactical Training system. The GAO further noted that the first device is the Close Combat Tactical Trainer for armor and mechanized infantry forces. The GAO explained that the Close Combat Tactical Trainer is expected to be followed, in sequence, by (1) an Aviation Combined Arms Tactical Trainer, (2) an Air Defense Combined Arms Tactical Trainer, (3) an Engineering Combined Arms Tactical Trainer, and (4) the Closed Loop Artillery Simulation. The GAO further explained that the Army is also considering other potential systems for intelligence and electronic warfare. (pp. 20-21/ GAO Draft Report)

Now on pp. 13-14.

DOD RESPONSE: Partially concur. The Army has no established sequence for follow-on trainers as part of the Combined Arms Tactical Trainer family.

See comment 1.

• **FINDING E: Concerns Regarding Simulation Management.** The GAO reported that, since 1976, reports by various DoD and Military Service study panels and independent audit groups have reflected concerns about the management of modeling and simulation activities. The GAO noted that a 1988 study by the Defense Science Board Task Force identified many problems with the management of modeling and simulation activities. The GAO mentioned, for example, that the study revealed that Service and individual joint commanders did not coordinate with each other when building or modifying automated training simulations--and, therefore, built duplicate models. The GAO also noted that the House Armed Services Committee expressed concerns about the adequacy of DoD-wide coordination involving computer simulation technology that in its August 1990 Authorization Report for Fiscal Year 1991 Defense Authorizations. The GAO added that the Committee recommended the establishment of a central office to coordinate the technology throughout the DoD and raised questions about the adequacy of the Close Combat Tactical Trainer program management. (pp. 21-23/GAO Draft Report)

Now on pp. 14-15.

DOD RESPONSE: Concur.

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Now on pp. 17-19.

• **FINDING F: Efforts to Strengthen Coordination and Management of Simulation Activities.** The GAO reported that, in June 1991, in response to the growing concerns about the inadequacy of DoD coordination and the lack of guidance dealing with simulation activities, the Deputy Secretary of Defense established the Defense Modeling Simulation Office. The GAO observed that the Defense Modeling Simulation Office operates under the guidance of a high-level executive council, chaired by the Director of Defense Research and Engineering. The GAO noted that in FY 1993, the Defense Modeling Simulation Office expects to issue a DoD directive outlining requirements for a DoD-wide approach for developing and using models and simulations. The GAO also noted that a draft of the directive requires the Military Services and the DoD organizations to implement management systems to oversee their modeling and simulation activities, and to facilitate interservice coordination. The GAO determined that the Defense Modeling Simulation Office is seeking to foster the development of Defense-wide standards, data bases, and communications capabilities in the simulation area, and the Defense Modeling Simulation Office is pursuing the goals through functional and technical working groups and by funding various simulation projects submitted by the Services, the Joint Staff, and Defense Agencies. (pp. 26-30/GAO Draft Report)

DOD RESPONSE: Concur.

• **FINDING G: Need for Long Range Master Plan and Controls Over Simulation Development.** The GAO reported that in the May 1992 Defense Modeling And Simulation Initiative management plan, the Defense Modeling and Simulation Office outlined its vision, goals, objectives, investment strategy, and future activities. In this plan, the GAO indicated, the Defense Modeling and Simulation Office recognizes that the DoD does not have a unified statement of modeling and simulation needs and deficiencies across the DoD. To help identify needs and deficiencies in the simulation area, the GAO observed, the Defense Modeling and Simulation Office is conducting workshops with representatives of functional communities, such as training and test and evaluation, from each of the Services, the Commander in Chief, Defense Agencies, and Federally Funded Research and Development Centers. The GAO mentioned that, by March 1993, the Defense Modeling and Simulation Office expects to summarize and publish the results of the workshops.

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Now on pp. 19-20.

The GAO also reported that the Defense Modeling and Simulation Office and other simulation experts recognize the need to improve controls over the development and use of models and simulations. The GAO assessed that two areas of particular concern to the Defense Modeling and Simulation Office are configuration management and the verification, validation, and accreditation of models. The GAO reported that, in beginning to address these issues, the Defense Modeling Simulation Office has included in a draft DoD directive on models and simulations a requirement that the Military Services and other Defense organizations assign responsibility for configuration control to a specific organization. The GAO also noted that the Defense Modeling and Simulation Office has included in its draft directive a requirement for the Services to establish a verification, validation, and accreditation program. (pp. 30-32/ GAO Draft Report)

See comment 1.

DOD RESPONSE: Concur. The workshop results were published as a Defense Technical Information Center report in March 1993. The draft Department of Defense Directive is in the final stages before being issued. Approval by the Secretary of Defense is anticipated by May 1993.

Now on pp. 20-21.

• FINDING H: Defense Modeling and Simulation Office Staffing and Funding. The GAO found that the Defense Modeling and Simulation Office lacks permanent personnel billets and operates with a temporary staff that has fluctuated in size from approximately six to eight Government personnel on loan from the Services. The GAO determined that the staff is augmented by up to eight staff years of contractor support. The GAO reported that Defense Modeling and Simulation Office officials have sought, but not yet obtained, some permanent staffing authority. Although the Congress strongly supported the Defense Modeling and Simulation Office by creating and initially funding it, the GAO speculated that internal DoD budget reviews have created uncertainty about future funding prospects. (pp. 32-34/GAO Draft Report)

DOD RESPONSE: Concur. The provision of permanent personnel billets is being pursued. A military (06) billet has already been provided and will be used for the DMSO Director. Funding has been stabilized with the inclusion of the Defense Modeling and Simulation Office in the Program Objective Memorandum.

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• FINDING I: Overlapping Roles Between Joint Staff Offices. The GAO observed that, in contrast with the Defense Modeling and Simulation Office, which is filling a broader mandate and more of an integrating role across the Military Services, the efforts of the Joint Staff focus on joint operational matters involving the Commanders in Chief. The GAO concluded, however, that two separate Joint Staff directorates have overlapping responsibilities in providing simulation assistance to the Commanders in Chief and each brings a different perspective on how to provide such support.

The GAO found that J-7 oversees operations of the Joint Warfare Center--and, in March 1992, J-7 established a Joint Simulation and Interoperability Division and tasked it to coordinate modeling and simulation activities involving the Commanders in Chief. The GAO observed that the Joint Simulation and Interoperability Division mission is to promote the application of models and simulations in joint operational planning and execution, education, training, exercises, operations requirements, joint test and evaluation, and doctrine development and evaluation.

The GAO further found that, at the same time, J-8 is tasked with developing joint modeling and simulation capabilities as necessary to support assigned missions, including conducting joint war games and interagency politico-military seminars and simulations. The GAO determined that J-8 assigned missions were not changed with the creation of the Joint Simulation and Interoperability Division. The GAO observed that, according to the J-8 technical director, J-8 has long been responsible for providing or arranging for simulation support to the Commanders in Chief across a broad spectrum of functions, including training, education, operational planning, and analysis. The GAO also reported that J-8 is the focal point for the Joint Staff Modern Aids to Planning Program--through which Commanders in Chief obtained their own simulation capabilities (hardware and software).

The GAO noted one area of long standing concern to the Congress has been the lack of a clear assessment of Commander in Chief simulation requirements. The GAO found that both of the Joint Staff directorates claim some responsibility for completing that assessment, and both directorates have been surveying the Commanders in Chief to determine their simulation needs. The GAO also observed that, at the same time, some Commanders in Chief have expanded their own simulation capabilities from other

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Now on pp. 21-24.

See comment 1.

Commanders in Chief to determine their simulation needs. The GAO also observed that, at the same time, some Commanders in Chief have expanded their own simulation capabilities from other simulation centers operated by the Army and Air Force. The GAO concluded, therefore, that at the present time, simulation support for Commanders in Chief activities comes from multiple sources within and external to the Joint Staff. The GAO did note that J-7 is currently conducting a study to assess whether a consolidated joint training, doctrine, and simulation command is needed. In addition, the GAO found two other efforts are underway that might eliminate some of the overlap:

- the Vice Director of the Joint Staff plans to initiate, in March 1993, a two-month study of the organization and staffing of the Joint Staff; and

- the Chairman, in response to legislative requirements, is conducting a comprehensive study of the roles and missions of the Armed Forces. (pp. 34-39/GAO Draft Report)

DOD RESPONSE: Partially concur. One of the ongoing Joint Staff studies, expected to be completed in June 1993, is being conducted under the direction of the Director, Joint Staff. Part of that study concerns whether a consolidated joint training, doctrine, and simulation "center" is needed. The study is not addressing a consolidated joint training, doctrine, and simulation "command".

Joint Administrative Publication 1.1, "Organization of and Functions of the Joint Staff," assigns modeling and simulation responsibility/proponency to several Joint Staff directorates, including J-4 (Logistics), J-6 (Command and Control), J-7 (Interoperability and Training), and J-8 (Force Structure and Assessment). Directorate modeling and simulation activity within those assigned areas is appropriate and does not constitute duplication or overlap of effort.

The GAO report accurately reflects the status of ongoing Joint Staff studies that will clarify the use and application of modeling and simulation technology in support of the Chairman of the Joint Chiefs of Staff, the Joint Staff, and the Unified and Specified Commanders. These efforts will help maximize the utilization of ever scarcer modeling and simulation resources.

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• **FINDING J: Army Strengthens Simulation Management and Ensure System Interoperability**. The GAO observed that, in responding to concerns about the management of the Combat Tactical Trainer and other simulation systems, the Army strengthened its management structure for acquiring simulations. The GAO noted that the revised structure is intended to elevate acquisition decisions to a higher level and to ensure more direct involvement of the Army Acquisition Executive--a role filled by the Assistant Secretary of the Army for Research, Development, and Acquisition.

The GAO reported that, in November 1991, the Army developed a master plan to outline the management structure for acquiring the Close Combat Tactical Trainer and other simulations in the Combined Arms Tactical Training system. The GAO observed that the master plan stated Combined Arms Tactical Training is not a single training system--but is, instead, a series of unique training devices for each of the Army's combat forces--for example armor, aviation, air defense, artillery. The GAO noted that future Combined Arms Tactical Training component acquisitions are expected to follow the same acquisition process as the Close Combat Tactical Trainer. The GAO also noted that, because of its estimated cost in excess of $1 billion and high visibility, the Close Combat Tactical Trainer was designated as a category II major defense acquisition program. Such a designation, the GAO mentioned, requires the Army Acquisition Executive to approve key acquisition decisions following milestone reviews by the Army Systems Acquisition Review Council. (In report table 3.1, the GAO delineated Close Combat Tactical Trainer milestones as of December 1992.)

Like Close Combat Tactical Trainer, the GAO reported each follow-on Combined Arms Tactical Training component is expected to be acquired as a major, separate, stand-alone system with funding budgeted as a separate program line item. The GAO also reported that, on November 30, 1992, the Army awarded a contract--valued at $409 million--to International Business Machines, Inc., to begin full-scale development of the Close Combat Tactical Trainer. The GAO observed that, in August 1992, the Army created a new major subordinate command--known as the Simulation, Training, and Instrumentation Command--to centralize oversight of technology development and life cycle support for training devices--i.e., instrumentation, targets, and threat simulations, as well as other Army battlefield simulations. The GAO noted that the new structure provides more direct lines of communication with the Army Acquisition Executive in major

Now on pp. 26-28.

See comment 1.

Now on p. 28.

decisions affecting Combined Arms Tactical Training components. The GAO also noted that the Army appointed a separate Project Manager for Combined Arms Tactical Training to manage the development and fielding of the Close Combat Tactical Trainer and other Combined Arms Tactical Training systems. (pp. 41-46/ GAO Draft Report)

DOD RESPONSE: Concur. For accuracy, the words "full-scale development" used to describe the acquisition of the Close Combat Tactical Trainer should be changed to "engineering and manufacturing design".

• **FINDING K: Steps Taken to Ensure Interoperability Among Combined Arms Tactical Training Components.** The GAO reported that the Army has taken steps to ensure interoperability and compatibility among Combined Arms Tactical Training components by (1) mandating the use of the DoD standard military programming language and (2) requiring an "open systems design" where interfaces between hardware and software do not depend on vendor-specific or proprietary equipment. The GAO further reported that, moreover, the Army is taking a leadership role in pursuing the development of standards to govern future Army and DoD simulations and ensure their interoperability. The GAO concluded that the Army has included requirements in the Combined Arms Tactical Training master plan and the Close Combat Tactical Trainer specifications to ensure interoperability among simulator systems. (p. 46/GAO Draft Report)

DOD RESPONSE: Concur.

• **FINDING L: Lack of Validated Data on Mix of Simulations and Field Training.** The GAO also reported that the Army is developing a combined arms training strategy to help manage its training resources in a more integrated manner. The GAO observed that the strategy--to establish a definitive relationship between the mix of field and simulation training--is still evolving, and it is not clear when definitive data will be available to provide precise answers to questions about (1) the most appropriate mix of field and simulation training, (2) the best combination of Combined Arms Tactical Training systems the Army will need, or (3) the extent to which they will be linked together to train higher echelons. The GAO also observed that plans for the Close Combat Tactical Trainer and other Combined Arms Tactical Training systems initially

focused on integrating simulations and field training at the battalion level. The GAO found, however, that the Army now plans to use the Close Combat Tactical Trainer at the platoon and Company levels due, in part, to cost considerations.

The GAO noted that individual training strategies are being developed by the Army training centers and schools to identify the best mix of training resources and to help ensure that the training effectiveness of a training device is determined before critical acquisition decisions are made.

In report table 4.1, the GAO summarized the quantities and the delivery schedule for the estimated 546 total Close Combat Tactical Trainer units needed to train the active and reserve armor units at the echelons of company level and below. The GAO acknowledged that Army officials recognize their numbers are tentative and must be validated through user testing. The GAO identified the following three key questions that should be answered from user testing:

- how long and at what intervals should units train on the Close Combat Tactical Trainer;

- to what extent should the Close Combat Tactical Trainer be used as a prerequisite to certain field exercises; and

- to what extent should the Close Combat Tactical Trainer be used to reinforce or sustain skills previously acquired.

The GAO explained that, in developing its acquisition plan, the Army subjectively decided to configure 20 percent of the total Close Combat Tactical Trainer units as mobile sites. The GAO further explained that a subjective decision was necessary because the Army did not have experience with mobile units to provide a more informed basis for its decision. The GAO acknowledged that the Army recognizes the most appropriate mix between field training days and simulation time for other Combined Arms Tactical Training systems also is still subject to validation. The GAO observed that the ultimate mix of Combined Arms Tactical Training systems is unclear at this time, because the Army does not know how often the Close Combat Tactical Trainer and other systems will be used independently or networked at higher echelons and because it has yet to validate the affordability of the complete Combined Arms Tactical Training system. (pp. 47-52/GAO Draft Report)

Now on pp. 30-33.

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DOD RESPONSE: Concur.

• **FINDING M: Uncertainty About Close Combat Tactical Trainer's Cost.** The GAO reported that the Army System Acquisition Review Council tentatively approved the Close Combat Tactical Trainer development at the June 1991 combined milestone I/II review, in part, on the basis of preliminary cost and training effectiveness data that Army officials recognized as "soft" and requiring further validation. The GAO pointed out that, although the preliminary cost analysis concluded that the Close Combat Tactical Trainer had the potential to be a cost-effective addition to the Army training program and could probably pay for itself, it was also recommended that the savings be quantitatively validated based on the result of user testing. The GAO also reported the October 1991 review council approval stated that potential reductions in training resources due to the Close Combat Tactical Trainer must be validated by test results and not based on artificial numbers. The GAO observed that cost and training effectiveness are scheduled to be reassessed before the Army decides whether to proceed with the full production of the Close Combat Tactical Trainer in 1997.

The GAO noted that, while the reliability of the cost data in the preliminary analysis is questionable, documentation associated with that analysis indicates the Army's intent to assess the feasibility of offsetting costs of the Close Combat Tactical Trainer through reduced field training funds in the future. Further, the GAO noted, the Army Acquisition Executive, in his milestone I/II approval memorandum, stated that (1) the Army was committed to the identification of specific field training costs reductions that are made possible by the introduction of the Close Combat Tactical Trainer system, and (2) where practicable, the savings resulting from such reductions will be used to offset the costs of developing and fielding a Combined Arms Tactical Training program and to expand the company level capability of Close Combat Tactical Trainer to the battalion level. The GAO noted that Program officials cautioned, however that the Army has not decided how much of its field training resources it is willing to give up to pay for the Close Combat Tactical Trainer system--and remained firm that any tradeoffs should begin only after the system, is in the field. The GAO reported that system fielding is scheduled for August 1998. Although the preliminary cost analysis indicated the system could pay for itself, the GAO found that the estimated

Now on pp. 33-35.

costs of preplanned product improvements were not included in the analysis. The GAO indicated the preplanned improvements include simulation for such features as (1) electronic warfare, (2) nuclear, biological and chemical effects, (3) dynamic terrain, (4) long-haul networks, (5) battalion sets, and (6) additional modules to simulate the armored combat earthmover and the air defense antitank system.(pp. 53-56/ GAO Draft Report)

DOD RESPONSE: Concur.

• **FINDING N: Testing Is Critical for Assessing Cost and Training Effectiveness.** The GAO reported that the Close Combat Tactical Trainer acquisition plan calls for formal operational and performance testing prior to the milestone III production decision. The GAO observed that technical tests by both the contractor and the Government are scheduled to be performed over a period of about 14 months (beginning in June 1995). The GAO noted the testing will ensure that system specifications are met. The GAO further noted that the technical tests will also include an independent verification and validation of the software by the Army Test and Evaluation Command to ensure the clarity, completeness, consistency, and traceability of the software to the system requirements. The GAO explained that the Project Manager for Combined Arms Tactical Training will be responsible for ensuring that the verification and validation is performed properly and concurrently with the software development, starting shortly after the contract is awarded and continuing into full production. The GAO speculated that performing the independent verification and validation concurrently with the software development should help identify potential technical problems and outline solutions before the system is completed.

The GAO also reported that user tests, also called operational tests, are currently scheduled to be performed at Fort Hood, Texas, beginning in December 1996. The GAO noted that testing is intended to evaluate training effectiveness through a series of company-sized field experiments for tank and mechanized infantry units. The GAO summarized in Table 4.2, the various mixes of traditional field training and Close Combat Tactical Trainer simulation training as outlined in the October 1991 Test and Evaluation Master Plan. The GAO reported that a detailed plan linking the functions to be tested with the test scenarios is scheduled to be completed and approved by October 1995.

Now on pp. 35-37.

The GAO concluded, however, that one limitation of the Close Combat Tactical Trainer test plan is that none of the training mixes includes a Close Combat Tactical Trainer-only scenario. contrasted with a field training-only scenario. The GAO asserted that such a comparison might give even greater insight into the training benefit of simulations compared with the more traditional forms of training. The GAO pointed out its review of the master test plan indicated that the user testing section is more comprehensive than prior Simulation Networking. The GAO referenced that the 1991 Close Combat Tactical Trainer test and evaluation master plan, which estimated that about $15 million will be needed to complete the technical and user tests, but that estimates provided by Army officials in December 1992 indicated the costs could range upwards to $19 million.(pp. 56-61/GAO Draft Report)

DOD RESPONSE: Partially concur. The Army's training effectiveness evaluation is the most comprehensive ever devised in the DoD. The greatest limitation will be in (1) acquiring sufficiently large groups to ascertain statistically significant results and (2) controlling or randomizing all of the variables. The study could be supplemented by low cost assessment of variously configured Close Combat Tactical Trainer prototypes for device to device comparisons.

See comment 4.

The GAO states the facts correctly. However, the GAO's conclusion that a limitation exists because the test plan does not include a Close Combat Tactical Trainer exercise compared to a similar field exercise scenario is flawed. The test plan does not include this comparison because it is not part of our training strategy. The Close Combat Tactical Trainer is designed to be used as a pre-field and a post-field trainer It is not being designed as a replacement for actual field training. Therefore, there is no justification to execute a comparative test.

• **FINDING O: Production of Some Close Combat Tactical Trainer Units Before Testing and Production Decision.** The GAO reported that, because of pressures within the Army to have networked simulator capabilities that were greater than those available through Simulation Networking, the Army decided to field in the U.S. and Germany 68 limited-capability "Quick Start" Close Combat Tactical Trainer units in advance of formal system testing and a formal production decision. The GAO observed that, as a result, those units will be fielded more

Now on p. 38.

See comment 1.

Now on p. 38.

than 2-years earlier than full capability units, and about 7 months before the planned initiation of operational testing. (p. 47, pp. 61-62/GAO Draft Report)

DOD RESPONSE: Concur. The Quickstart decision was made based on the pressures to have a better system faster. However, over a period of time, Quickstart became an integral phase of the evaluation of training effectiveness and will be used to establish early user acceptance and validation. Furthermore, Quickstart Close Combat Tactical Trainer modules will be refurbished to the final Close Combat Tactical Trainer design upon the decision to initiate full production.

• **FINDING P: Caution in Accelerated Development and Fielding.** The GAO found that differences of opinion exist within the Army concerning the prospects for further accelerating Close Combat Tactical Trainer development and production. The GAO observed that it has reported extensively on the importance of conducting operational tests and evaluations prior to beginning full production. The GAO noted that failure to do so can result in higher program costs, future scheduling delays due to the need to make system modifications, and performance problems. The GAO concluded that pressures to further accelerate Close Combat Tactical Trainer development and production could produce pressures to shortcut required testing and analyses. The GAO asserted that any such short cutting of the critical reviews could limit (1) full disclosure of future program costs for the Close Combat Tactical Trainer, including possible costs of preplanned product improvements, (2) the Army's ability to assess more definitively the effectiveness of the system and its contribution to the right mix issue, and (3) insight into potential tradeoffs between simulations and resources required for traditional field training. (p. 47, pp. 62-64/GAO Draft Report)

DOD RESPONSE: Concur.

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RECOMMENDATIONS

• **RECOMMENDATION 1:** The GAO recommended that the Secretary of Defense ensure that the Defense Modeling Simulation Office is

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Now on pp. 5 and 25.

properly staffed to carry out its assigned responsibilities. (p. 8, p. 40/GAO Draft Report)

DOD RESPONSE: Concur. Action has been initiated to obtain permanent personnel billets. A military (06) billet has been provided and will be used for the DMSO Director.

Now on pp. 5 and 25.

• RECOMMENDATION 2: The GAO recommended that the Secretary of Defense eliminate the duplication and inefficiencies within the two Joint Staff directorates involved in simulations and clearly delineate each directorate's roles and responsibilities in this area. (p. 8, p. 40/GAO Draft Report)

DOD RESPONSE: Partially concur. Joint Administrative Publication 1.1, "Organization of and Functions of the Joint Staff ," currently assigns modeling and simulation responsibility/proponency to several Joint Staff directorates, including J-4 (Logistics), J-6 (Command and Control), J-7 (Interoperability and Training), and J-8 (Force Structure and Assessment). Directorate modeling and simulation activity within those assigned areas is appropriate and does not constitute unjustified duplication or overlap of effort.

The Joint Staff manages modeling and simulation activities as an integral part of its Information Resources Management Program. The Vice Director, Joint Staff is the Joint Staff senior Information Resources Management authority and has delegated to the Deputy Director for Technical Operations, J-8, the responsibility for coordination, planning, and management of modeling and simulation technology and technical operations.

The GAO report accurately reflects the status of ongoing Joint Staff studies that will clarify the use and application of modeling and simulation in support of the Chairman of the Joint Chiefs of Staff, the Joint Staff, and the Unified and Specified Commanders; so as to maximize the utilization of ever scarcer modeling and simulation resources. The first study on the roles and missions of the Chairman was completed in February 1993. The second study on the establishment of a Joint Service training, doctrine, and simulation center is ongoing and will be completed in June 1993. The final study on the reorganization of the Joint Staff was started in March 1993 and is expected to be completed by June 1993.

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be completed by June 1993.

• **RECOMMENDATION 3:** The GAO recommended that the Secretary of the Army ensure that all prerequisite testing, cost analyses, and training effectiveness assessments are completed and fully considered before decisions are made about full production of the Close Combat Tactical Trainer. (p. 8, p. 64/GAO Draft Report)

DOD RESPONSE: Concur. Of the two types of required testing (technical and operational), technical testing is straight forward and can be executed using established techniques. The intent of technical testing is to ensure the system complies with the requirements established by the user and implemented by the developer in the specification. The Close Combat Tactical Trainer will have all requisite technical testing performed. Technical testing is scheduled to start July 1996.

The operational testing, however, includes an unprecedented, critical issue on training transfer. Methodology must be developed to determine training transfer in a combined arms environment because of the myriad of variables involved in combined arms operations. This baseline will provide data to determine the magnitude of the effort required to establish the methodology to be employed on Close Combat Tactical Trainer. Operational testing is scheduled to begin December 1996.

All technical and operational tests will be completed by April 1997, prior to Milestone III, full Close Combat Tactical Trainer production.

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The following are GAO's comments on the Department of Defense's letter dated March 26, 1993.

GAO Comments

1. We have modified the report as appropriate.

2. We recognize, as stated in our report, that simulations have wide applicability within DOD beyond training, including the areas of education, military operations, research and development, test and evaluation, analysis, and production and logistics. However, the focus of this report was limited to training.

3. DOD's comments should not be interpreted as meaning that the Combined Arms Training Strategy is complete and capable of identifying the appropriate mix of field and simulation training. As noted in chapter 4, the strategy has not yet been finalized. Further, it is not clear when definitive data will be available to provide precise answers to questions about the most appropriate mix of field and simulation training. Such answers would likely vary for individual simulation systems. DOD concurred, without additional comment regarding our assessment of the training strategy contained in chapter 4.

4. DOD's position that the CCTT is designed to be used as a pre-field and a post-field trainer suggests that a CCTT-only test scenario might provide a clearer indication of the system's capabilities as a pre-field trainer.

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